TOSHIBA

2.5 type Hard Disk Drives

AL14SEB120N/NY
AL14SEB090N/NY
AL14SEB060N/NY
AL14SEB045N/NY
AL14SEB030N/NY
AL14SEQ120N
AL14SEQ090N
AL14SEQ060N
AL14SEQ045N
AL14SEQ030N

Product Specification

株式会社　東芝

TOSHIBA CORPORATION

No.
３６００７９３７０
TOTAL 92　CONT.ON　2　PAGE No. 1

Revision History

TOSHIBA

TITLE : 2.5 type Hard Disk Drives AL14SEB120/090/060/045/030N/NY- AL14SEQ120/090/060/045/030N

Product Specification

REV No.	DATE	CONTENTS	DEP.	REVISED	APP'D	STGE.PER.
00	2015-03-18	Initial issue	HDGI-2	O.Kawashima	T.Iwamoto	
01	2015-10-01	・Page 56-57 Added the information of "POWER DISABLE Control" ：Reserved (not used) →POWER DISABLE P3 in the Table 4.2 ：P1 to P3 → P1 to P2 at the "(*1), (*2)" ：Section 4.3.5. of "POWER DISABLE Control input signal" ・Page 1-3, 9, 23 Deleted the FIPS model (AL14SEQxxxNB type) ・Page 57 Added the information of "Vcc voltage range" in the section 4.3.3. ・The error in writing at information was corrected Page 21：Command-2 (SPC-2) → Command-4 (SPC-4) Page 23：One terabyte (TB) = one trillion bytes →One gigabyte(GB) = one billion bytes Page 10：2014/30/EU →2004/108/EC Page 24：W/R: 8.7W → 8.0W, 205 MiB/s → 196 MiB/s Page 26：1 ms duration → 2 ms duration	HDGI-2	O.Kawashima	T.Iwamoto	

Preface

This document describes the 10,500 rpm AL14SEB120N/090N/060N/045N/030N / AL14SEB120NY/090NY/060NY/045NY/030NY / AL14SEQ120N/090N/060N/045N/030N 2.5 type hard disk drives with an embedded Serial Attached SCSI (SAS).

This document details the specifications and functions of the above hard disk drive, and gives the requirements and procedures for installing it into a host computer system.

This document is written for users who have a basic understanding of hard disk drives and their use in computer systems. The DOCUMENT ORGANIZATION section describes organization and scope of this document. The need arises, use the other documents.

The organization of this document, related reference document and conventions for alert messages follow.

Overview of Document

This document consists of the following seven chapters:

Chapter 1 General Description

This chapter introduces the hard disk drives standard features, hardware, and system configuration.

Chapter 2 Specifications

This chapter gives detailed specifications of the hard disk drives and the installation environment.

Chapter 3 Data Format

This chapter describes the data structure, the addressing method, and the defect management.

Chapter 4 Installation Requirements

This chapter describes the basic physical and electrical requirements for installing the hard disk drives.

Chapter 5 Installation

This chapter explains how to install the hard disk drives. It includes the notice and procedures for setting device number and operation modes, mounting the hard disk drive, and confirming drive operation.

Chapter 6 Diagnostics and Maintenance

This chapter describes the automatic diagnosis, and maintenance of the hard disk drive. This chapter also describes diagnostic methods for operation check and the basics of troubleshooting the hard disk drives.

Chapter 7 Error Analysis

This chapter describes in details how collect the information for error analysis and how analyze collected error information.

Conventions Used in this Document

The AL14SEB/SEQ series are described as "the HDD" in this document.

Decimal number is represented normally.

Hexadecimal number is represented as X'17B9', 17B9h or 17B9H.

Binary number is represented as "010".

Safety Precautions

This section lists important precautions which users of our product(s) (and anyone else) should observe in order to avoid injury to human body and damage to property, and to ensure safe and correct use of our products. Please be sure that you understand the meanings of the labels and graphic symbols described below before you move on to the detailed descriptions of the precautions, and comply with the precautions stated.

Explanation of Labels

⚠DANGER	⚠WARNING	⚠CAUTION	*NOTICE*
Indicates a hazardous situation which, if not avoided, will result in death or serious injury[1].	Indicates a hazardous situation which, if not avoided, could result in death or serious injury[1].	Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury[2].	Indicates practices that may cause property damage[3] and other problems, but not personal injury

1. Serious injury includes blindness, wounds, burns (low and high temperature), electric shock, fractures, and poisoning, etc. with long-lasting effects or that require hospitalization and/or long-term hospital visits for treatment.
2. Minor or moderate injury includes wounds, burns, electric shock, etc. not requiring hospitalization and/or long-term hospital visits for treatment.
3. Property damage means damage to customer or third party machines and equipment.

Explanation of Graphic Symbols

Prohibited	**Instructions**
Indicates prohibited actions.	Indicates actions that must be undertaken for safety purposes.

⚠CAUTION	
Prohibited	Electrical shock Do not touch the HDDs while power-feeding.
Prohibited	Damage 1) Do not use a conductive cleaner to clean the HDDs. 2) Do not remove any labels from the HDD or deface the HDDs in any way. 3) Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy HDDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.

⚠CAUTION	
 **Instructions**	High temperature To prevent injury such as burn, do not touch the HDD while it is hot. The HDA and LSI become hot during operation and remain hot immediately after turning off the power.
 **Instructions**	Damage Always ground yourself with such as a wrist strap connected to ground before handling. ESD (Electrostatics Discharge) may cause the damage to the device.
 **Instructions**	Damage When dismounting the HDD which is mounted on the system while power is supplied; 1) Stop the spindle motor by a START STOP UNIT command. It takes about 15 seconds for the spindle motor to stop completely. 2) Then, dismount the HDD using such as the HDD mounting/dismounting mechanism of the system. When removing the HDD, avoid exposing it to shock or vibration. Just in case, stop dismounting once and wait until the spindle motor stops (about 15 seconds) when SAS connector breaks off contact.
 **Instructions**	Damage When dismounting the HDD which is mounted on the system while power is not supplied; Dismount the HDD using such as the HDD mounting/dismounting mechanism of the system. When removing the HDD, avoid exposing it to shock or vibration.
 **Instructions**	Damage When storing or transporting the HDD, put it in the antistatic bag (refer to Section 5.1 and 6.5).

Related Standards

Product specifications and functions described in this document comply with the following ANSI (*1) standards and SFF Committee specifications.

Specification (document) number	Name	Concerned organization
T10/INCITS 513	Information technology SCSI Primary Commands-4 (SPC-4)	American National Standards Institute (ANSI)
T10/INCITS 514	Information technology SCSI Block Commands-3 (SBC-3)	American National Standards Institute (ANSI)
T10/INCITS 515	Information technology SCSI Architecture Model-5 (SAM-5)	American National Standards Institute (ANSI)
T10/INCITS 519	Information technology Serial Attached SCSI-3 (SAS-3)	American National Standards Institute (ANSI)
T10/INCITS 492	Information technology SAS Protocol Layer-3 (SPL-3)	American National Standards Institute (ANSI)
SFF-8201	Form Factor of 2.5" Disk Drives	SFF Committee
SFF-8223	2.5" Drive Form Factor with Serial Connector	SFF Committee

* ANSI = American National Standard Institute

In case of conflict between this document and any referenced document, this document takes precedence.

WEEE marking

Following information is only for EU-member states:

The use of the symbol indicates that this product may not be treated as household waste. By ensuring this product is disposed of correctly, you will help prevent potential negative consequences for the environment and human health, which could otherwise be caused by inappropriate waste handling of this product. For more detailed information about recycling of this product, please contact your local city office, your household waste disposal service or the shop where you purchased the product.

Compliance with Administration on the Control of Pollution Caused by Electronic Information Products of the People's Republic of China

环保使用期限标识是根据《电子信息产品污染控制管理办法》以及《电子信息产品污染控制标识要求 (SJ/T11364-2006)》、《电子信息产品环保使用期限通则》制定的，适用于中国境内销售的电子信息产品的标识。

只要按照安全及使用说明内容在正常使用电子信息产品情况下，从生产日期算起，在此期限内产品中含有的有毒有害物质不致发生外泄或突变，不致对环境造成严重污染或对其人身、财产造成严重损害。

产品正常使用后，要废弃在环保使用年限内或者刚到年限的产品，请根据国家标准采取适当的方法进行处置。

另外，此期限不同于质量/功能的保证期限。

The Mark and Information are applicable for People's Republic of China only.

<产品中有毒有害物质或元素的名称及含量>

部件名称	有毒有害物质或元素					
	铅(Pb)	汞(Hg)	镉(Cd)	六价铬(Cr(VI))	多溴联苯(PBB)	多溴二苯醚(PBDE)
HDD(硬盘驱动器)	X	O	O	O	O	O

O：表示该有毒有害物质在该部件所有均质材料中的含量均在电子信息产品中有毒有害物质的限量要求标准规定的限量要求(SJ/T11363-2006)以下

×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出电子信息产品中有毒有害物质的限量要求标准规定的限量要求(SJ/T11363-2006)

This information is applicable for People's Republic of China only.

This product is shipped as a component to manufacture the final products.
Therefore, the packaging material code provided in GB/T18455-2010 is not marked on any packaging part of this product.

Safety/EMC Standards

The drive satisfies the following standards.

	Applied standard
Underwriters Laboratories(UL)	UL60950-1
Canadian Standard Association(CSA)	CAN/CSA-C22.2.No.60950-1
Technischer Uberwachungs-Verein(TUV)	EN 60950-1
Bureau of Standards, Metrology and Inspection (BSMI)	CNS 13438 (CISPR Pub. 22 Class B):D33003
Ministry of Science, ICT & Future Planning (MSIP)	電磁波障害防止基準 KN22, KN24 (CISPR Pub. 22 Class B) (Note 1)
Australian Communications and Media Authority (ACMA)	AS/NZS CISPR22

(Note 1) Marks of KC

Made in Japan	1. 기기의 명칭(모델명) : AL14SEB120_030N/NY, AL14SEQ120_030N 2. 인증번호 : MSIP-REM-TSD-AL14SEB120N 3. 인증받은 자의 상호 : TOSHIBA CORPORATION 4. 제조년월일 : 2014-09 5. 제조자 / 제조국가 : TOSHIBA CORPORATION / 일본
Made in Philippines	1. 기기의 명칭(모델명) : AL14SEB120_030N/NY, AL14SEQ120_030N 2. 인증번호 : MSIP-REM-TSD-AL14SEB120N 3. 인증받은 자의 상호 : TOSHIBA CORPORATION 4. 제조년월일 : 2014-09 5. 제조자 / 제조국가 : TOSHIBA CORPORATION / 필리핀

B급 기기 (가정용 방송통신기자재)	이 기기는 가정용(B급) 전자파적합기기로서 주로 가정에서 사용하는 것을 목적으로 하며, 모든 지역에서 사용할 수 있습니다.

CE Marking

The drive satisfies the following standards.

Category	Applied standard	Issued year	Comment
EMC 2004/108/EC	Emission: EN55022	2010	Class B (including domestic environment)
	Immunity: EN55024	2010	Product immunity standard for IT-equipment
RoHS 2011/65/EU	EN50581	2012	Category 3

DOCUMENT ORGANIZATION

PRODUCT SPECIFICATION (This document)	1. General Description 2. Specifications 3. Data Format 4. Installation Requirements 5. Installation 6. Diagnostics and Maintenance 7. Error Analysis
SAS INTERFACE SPECIFICATION	1. SAS Interface 2. Command Processing 3. Data Buffer Management 4. Command Specifications 5. Parameter Data Formats 6. Sense Data and Error Recovery Methods 7. Disk Media Management
SAS/SATA SED SPECIFICATION	1. Introduction 2. Overview 3. Implementation Details 4. Error handling
SAS/SATA SIE SPECIFICATION	1. Introduction 2. Overview

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CHAPTER 1 General Description

This chapter describes the feature and configuration of the hard disk drives (HDDs).

The HDDs are high performance large capacity 2.5 type hard disk drives with an embedded Serial Attached SCSI (SAS) controller.

The interface used to connect the HDDs to the host system complies with ANSI T10/1601D Serial Attached SCSI-1.1 (SAS-1.1) and ANSI T10/1760D Serial Attached SCSI-3 (SAS-3), which covers items ranging from SAS physical layers to SCSI command protocols.

The high-speed data transfer and long-distance transmission capabilities of SAS technology and the powerful command set the HDDs facilitate creation of high-performance and highly reliable disk subsystems with large storage capacities.

1.1 Standard Features

(1) Compactness

The HDDs are a compact enclosure which complies with the 2.5 type hard disk drive form factor.

(2) Environmental Protection

The HDDs comply with the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS-2) directive issued by European Union (EU).

(3) SAS Standard

The HDDs are equipped with a serial attached SCSI (SAS) as a host interface.

- Transfer speed: 12 Gbit/s, 6 Gbit/s, 3 Gbit/s, 1.5 Gbit/s
- Number of SAS ports: Two
- Full-duplex (simultaneous bidirectional data transfer) is supported.

(4) Dual SAS port support

The HDDs have two pairs of driver and receiver set (PHY) for the SAS to support dual SAS port connection.

On HDDs, Primary and Secondary Ports on SAS plug connector (2 physical links plus power connections) are used for SAS port connection.

(5) High-speed data transfer

The maximum data-transfer speed is 1200 MB/s per SAS port. The large-capacity data buffer of the HDDs enable the effective use of such high-speed data transfers available on the SAS connection.

(6) Continuous block processing

The addressing method of data blocks is logical block address. The initiator can access data by specifying block number in a logically continuous data space without concerning the physical structure of the track or cylinder boundaries.

The continuous processing up to [64K-1] blocks in a command can be achieved, and the HDDs can perform continuous read/write operation when processing data blocks on several tracks or cylinder.

(7) Multi-segment data buffer

The data buffer is 128MiB. (1 MiB = 1,048,576 bytes) Data is transferred between SAS port and disk media through this data buffer. This feature provides the suitable usage environment for users.

(8) Cache feature

After executing the READ command, the HDDs read automatically and store (prefetches) the subsequent data blocks into the data buffer (Read-ahead caching).

The high speed sequential data access can be achieved by transferring the data from the data buffer without reaccessing the disk in case the subsequent command requests the prefetched data blocks.

The Write Cache feature is supported. When this feature is enabled, the status report is issued without waiting for completion of write processing to disk media, thereby enabling high speed write processing.

IMPORTANT

When Write Cache is enabled, you should ensure that the cached data is surely flushed to the disk media before you turn off the HDDs power.
To ensure it, you should issue either the SYNCHRONIZE CACHE command or the START STOP UNIT command with specifying "0" to the Immediate bit, and then confirm that the command is surely terminated with the GOOD STATUS.

(9) Command queuing feature

The HDDs can queue maximum 128 commands, and optimizes the issuing order of queued commands by the reordering function. This feature realizes the high speed processing.

(10) Reserve and release functions

The HDDs can be accessed exclusively in the multi-host or multi-initiator environment by using the reserve and release functions.

(11) Error recovery

The HDDs can try to recover from errors in the HDD using its powerful retry processing. If a recoverable data check occurs, error-free data can be transferred to the initiator after being corrected in the data buffer. The initiator software is released from the complicated error recover processing by these error recovery functions of the HDDs.

(12) Automatic alternate block reassignment

If a defective data block is detected during read or write the HDDs can automatically reassign its alternate data block.

(13) Programmable data block length

Data can be accessed in fixed-block length units. The logical data block length is programmable, and can be specified at initializing with the 512, 520 ,524, and 528 bytes.

IMPORTANT

Error rate increase

1. The HDD format at factory shipment is generally 512 bytes.
2. The recoverable error of the HDD might increase when the format would be modified from 512 bytes to the following values:
   520 bytes, 524 bytes and 528 bytes
3. The recoverable Error referred here is sense data (1-13-xx).

(14) Defective block slipping

A logical data block can be reallocated in a physical sequence by slipping the defective data block at formatting. This results in high speed contiguous data block processing without a revolution delay due to defective data block.

(15) High speed positioning

A rotary voice coil motor achieves fast positioning with high performance access control.

(16) Large capacity

A large capacity can be obtained from the HDDs by dividing all cylinders into several partitions and changing the recording density on each partition (constant density recording). The disk subsystem with large capacity can be constructed in the good space efficiency.

(17) Start/Stop of spindle motor

Using the SAS primitive or the SCSI command, the host system can start and stop the spindle motor.

(18) Diagnosis

The HDDs have a diagnostic capability which checks internal controller functions and HDD operations. Also, for early detection of and recovery from the errors on the disk, the HDD has a function for periodically implementing a full scan of the disk.

(19) Low power consumption

By using highly integrated LSI components, the power consumption of the HDDs is very low, and this enables the unit to be used in wide range of environmental conditions. Also, unloading the head with idle status realizes the significant reduction of power consumption.

(20) Low acoustic noise

The acoustic noise level is low. This makes it ideal for office use.

(21) Microcode downloading

The HDDs implement the microcode download feature. This feature easily achieves maintenance and function enhancement of the HDDs.

(22) Self Encryption Drive (SED)

SED model is available in this HDD series. SED model is TCG (Trusted Computing Group) protocol. This function will prevent information leakage if stolen or missing the HDD, so it is a good data security from accident.
Refer to SAS/SATA SED Specification (360078691) for more detail.

(23) Sanitize Instant Erase (SIE) functions

SIE model is available in this HDD series. SIE model is supported sanitize device feature set and TCG is not supported. When the deletion of data is executed by using this function, the HDDs cannot restore all this recorded data.
Refer to SAS/SATA SIE Specification (360078692) for more detail.

1.2 Hardware Structure

The HDDs have a head disk assembly(HDA) and a printed circuit board assembly (PCBA). The HDA includes heads on an actuator and disks on a spindle motor mounted on the HDA. The PCBA includes a read/write circuit and a controller circuit.

(1) Disks

The disks have an outer diameter of 65 mm {2.56 inch}.

(2) Heads

The heads have MR (Magnet-Resistive) read element Ramp Load type slider.

(3) Spindle motor

The disks are rotated with an FDB (Fluid Dynamic Bearing) motor. The specified speed of the motor is maintained with the motor terminal's counter electromotive voltage, which is used to detect the motor speed.

(4) Actuator

The actuator, which uses a rotary voice coil motor (VCM), consumes little power and generates little heat. The heads at the end of the actuator arm are controlled and positioned via feedback servo loop.

The heads are positioned on the ramp when the power is off or the spindle motor is stopped.

(5) Read/write circuit

The read/write circuit uses a LSI chip for the read/write preamplifier and an PRML (Partial Response Maximum Likelihood)＋Iterative modulation/demodulation circuit in order to prevent errors being triggered by external noise and to improve data reliability.

(6) Controller circuit

The controller circuit supports SAS (Serial Attached SCSI) interface, and it realized a high performance by integration into LSI.

1.3 System Configuration

For the Serial Attached SCSI, the ANSI standard defines Point-to-Point technology. Figure 1.1 and Figure 1.2 give examples of the SAS system configuration.

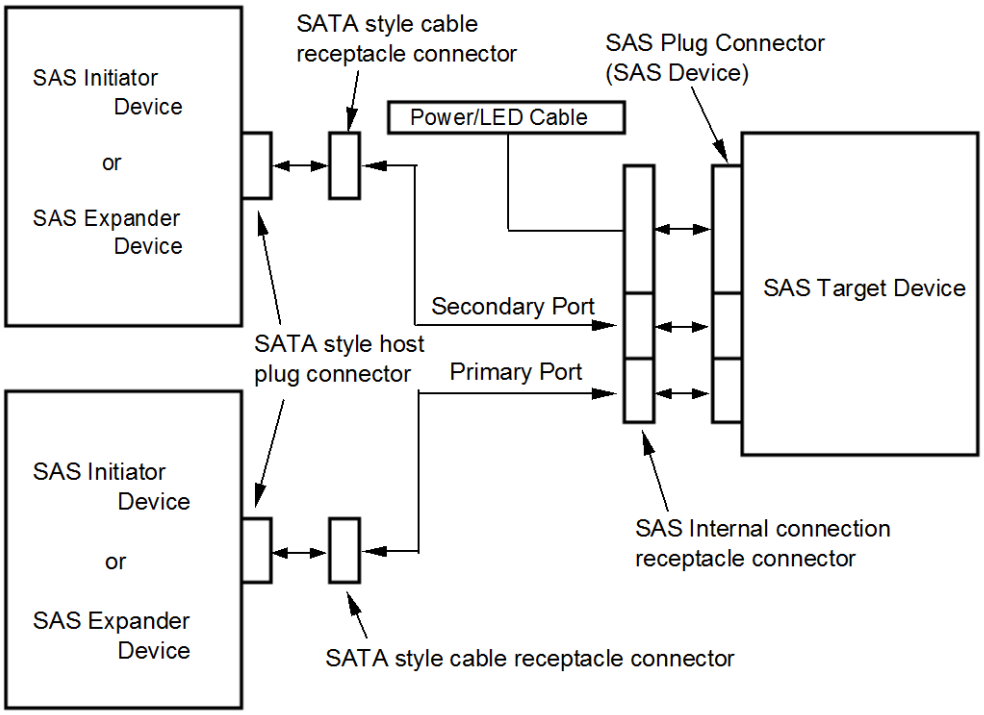


Figure 1.1 Example of SAS system configuration (Dual port internal cabled environment)

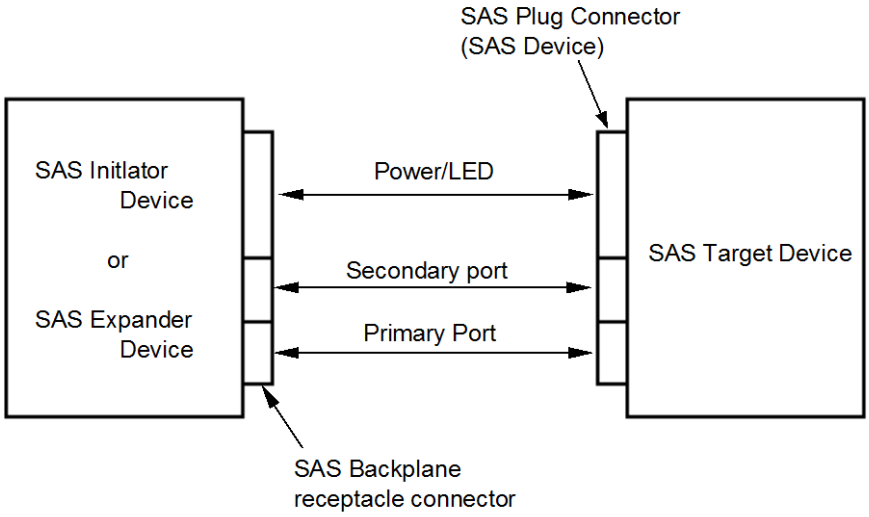


Figure 1.2 Example of SAS system configuration (Dual port internal backplane environment)

(1) Port addressing

Every device connected with the SAS protocol has an unique address (SAS address). SAS addresses are in the Name Address Authority (NAA) IEEE Registered format defined by SCSI Primary Command-4 (SPC-4).

An SAS address consists of 8 bytes as a unique value set for each device.

The initiator can implement an I/O operation on an HDD by using the corresponding SAS address stored by the HDDs.

CHAPTER 2 Specifications

This chapter describes specifications of the HDDs.

2.1 Hardware Specifications

2.1.1 Model Number

Each model has different recording capacities when shipped.

Table 2.1 lists the model number.

The data format can be changed by reinitializing with the user's system.

Table 2.1 Model numbers

Model number	Interface type	Capacity (*1) (user area)	Model type (*2)	Function	
				SDFS (*3)	TCG (*4)
AL14SEB120N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	1200 GB (*1)	Base	No	No
AL14SEB090N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	900 GB (*1)	Base	No	No
AL14SEB060N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	600 GB (*1)	Base	No	No
AL14SEB045N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	450 GB (*1)	Base	No	No
AL14SEB030N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	300 GB (*1)	Base	No	No
AL14SEB120NY	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	1200 GB (*1)	SIE	Yes	No
AL14SEB090NY	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	900 GB (*1)	SIE	Yes	No
AL14SEB060NY	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	600 GB (*1)	SIE	Yes	No
AL14SEB045NY	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	450 GB (*1)	SIE	Yes	No
AL14SEB030NY	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	300 GB (*1)	SIE	Yes	No
AL14SEQ120N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	1200 GB (*1)	SED	Yes	Yes
AL14SEQ090N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	900 GB (*1)	SED	Yes	Yes
AL14SEQ060N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	600 GB (*1)	SED	Yes	Yes
AL14SEQ045N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	450 GB (*1)	SED	Yes	Yes
AL14SEQ030N	SAS-3.0 (12 / 6 / 3 / 1.5 Gbit/s)	300 GB (*1)	SED	Yes	Yes

(*1) One gigabyte(GB) = one billion bytes; accessible capacity will be less and actual capacity depends on the operating environment and formatting.

(*2) Model type is displayed as Base, SIE (Sanitize Instant Erase), and SED (Self Encrypting drive) .

(*3) SDFS : Sanitize Device Feature Set

(*4) TCG : TCG Enterprise SSC

2.1.2 Function Specifications

Table 2.2 shows the function specifications of the HDDs.

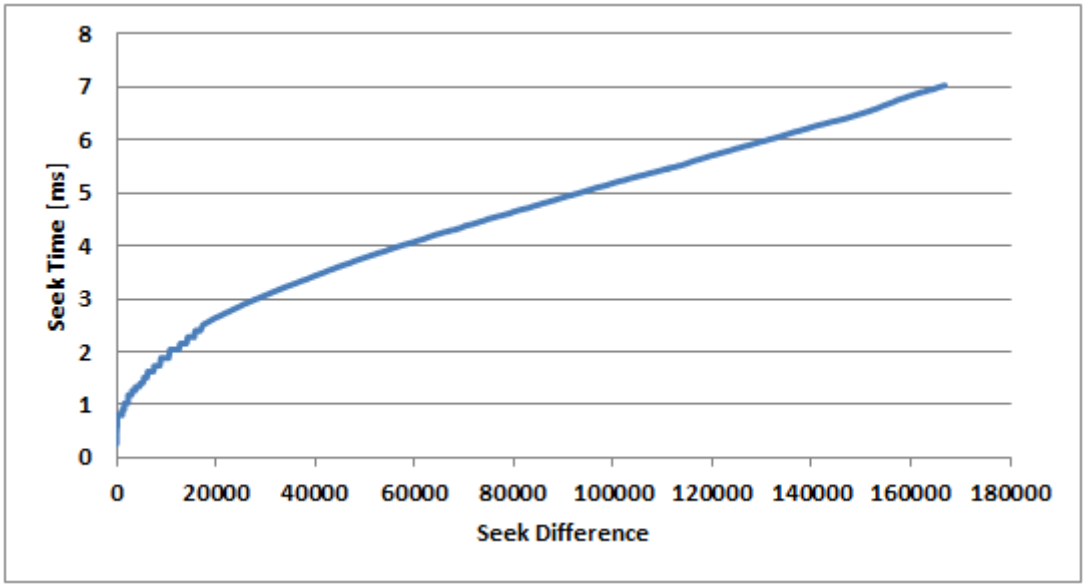
Table 2.2 Function specifications

Item		Specification				
		AL14SEB120N AL14SEQ120N	AL14SEB090N AL14SEQ090N	AL14SEB060N AL14SEQ060N	AL14SEB045N AL14SEQ045N	AL14SEB030N AL14SEQ030N
Formatted capacity (*1)		1200 GB (*2)	900 GB (*2)	600 GB (*2)	450 GB (*2)	300 GB (*2)
Recording method		RS ECC less LDPC				
Seek time (*3) (Read/Write)	Track to track	0.2 ms / 0.3 ms				
	Average	3.7 ms / 4.1 ms				3.5 ms / 3.9 ms
	Full stroke	7.5 ms / 8.5 ms				
Rotation speed		10,500 rpm				
Average latency time		2.86 ms				
Start/stop time (*4)	Ready up time	15 s Typ. (30 s Max.)				
	Stop time	15 s Typ.				
External dimensions	Height	15.0 mm +0,-0.5 mm				
	Width	69.85 mm ±0.25 mm				
	Length	100.45 mm Max.				
Weight		230 g Max.				
Power consumption (*5)	W/R (200I/O)	8.0 W Max.				
	Ready (Idle A)	4.6 W Typ.				
	Idle B	4.0 W Typ.				
Data transfer speed (*6)	Sustained	196 MiB/s				
	External	12 Gbit/s, 6 Gbit/s, 3 Gbit/s, 1.5 Gbit/s				
Logical data block length (fixed length) (*7)		512 B, 520 B, 524 B, 528 B				
Related standards		T10/INCITS-513 (SPC-4), T10/INCITS-514 (SBC-3), T10/INCITS-515 (SAM-5), T10/INCITS-519 (SAS-3), T10/INCITS-492 (SPL-3), SFF-8201, SFF-8223				
Buffer size		128 MiB (*8)				
Acoustics (Sound Power of Ready)		32 dB Typ.				

(*1) The formatted capacity can be changed by changing the logical block length and using spare sector space. See CHAPTER 3 for the further information.

(*2) One gigabyte (GB) = one billion bytes; accessible capacity will be less and actual capacity depends on the operating environment and formatting.

(*3) The seek time is as follows (Example; AL14SEB120N)



(*4) The start time is the time from power on or start command to when the HDDs are ready, and the stop time is the time for disks to completely stop from power off or stop command.

(*5) Power supply at nominal voltage ±1%. 25°C ambient. Refer to Subsection 2.5 "Power conditions" of the SAS INTERFACE SPECIFICATION for details of idle and ready states. "Ready state" corresponds to 2.5.2 "Active state" of the SAS INTERFACE SPECIFICATION.

(*6) The maximum data transfer speed may be restricted to the response speed of initiator and by transmission characteristics.
1 MB/s = 1,000,000 bytes/s. 1 MiB/s = 1,048,576 bytes/s

(*7) Refer to item (13) in Subsection 1.1.

(*8) 1 MiB = 1,048,576 bytes

2.1.3 Environmental Specifications

Table 2.3 lists environmental and power requirements.

Table 2.3 Environmental/Power requirements

Item			Specification				
			AL14SEB120N AL14SEQ120N	AL14SEB090N AL14SEQ090N	AL14SEB060N AL14SEQ060N	AL14SEB045N AL14SEQ045N	AL14SEB030N AL14SEQ030N
Temperature (*1)	Operating		5 to 55 °C				
	Non-operating		–40 to 70 °C				
	Transport		–40 to 70 °C				
	Enclosure surface temperature at operating		5 to 60 °C				
	Gradient		20 °C/h or less				
Relative humidity	Operating		5 to 95 %RH				
	Non-operating		5 to 95 %RH				
	Transport (with packing)		5 to 95 %RH				
	Max. wet bulb temperature		29 °C (no condensation)				
Vibration (*2)	Operating (*3)		0.6 mm (5 to 20Hz) / 1G (20 to 300Hz) or less				
	Non-operating (*4)		3.1 mm (5 to 20Hz) / 5G (20 to 300Hz) or less				
Shock (*2)	Operating		100G / 2 ms duration				
	Non-operating		400G / 2 ms duration				
Altitude	Operating		–305 to +3,048 m				
	Non-operating		–305 to +12,192 m				
Power requirement (*5)	+12V DC	Regulation	±5%				
		Ready (average)	0.25A				
		Spin up	1.65A (peak)				
		Peak operating current max. (peak) DC (*6)	1.40A				
		Operating current DC (reference) (*6)	0.49A				
	+5V DC	Regulation	±5% (*7)				
		Ready (average)	0.32A				
		Peak operating current max. (peak) DC (*6)	1.20A				
		Peak operating current DC (reference) (*6)	0.80A				
	Ripple (+5V, +12V)		250mVp-p or less (*8)				

(*1) For detail condition, see Section 4.1.

(*2) Vibration applied to the HDD is measured at near the mounting screw hole on the frame as much as possible.

(*3) At random seek write/read and default on retry setting with log sweep vibration.

(*4) At power-off state after installation

(*5) Input voltages are specified at the HDD connector side, during HDD ready state.

(*6) Operating currents are values under W/R operation(200I/O).

(*7) Make sure the value is not less than −0.3V DC (less than –0.6V, 0.1ms) when turning on or off the power.

(*8) High frequency noise (over 20MHz) is less than 100 mVp-p.

2.1.4 Error Rate

Errors detected during initialization and replaced by alternate block assignments are not included in the error rate. Data blocks to be accessed should be distributed over the disk equally.

(1) Unrecoverable error rate

Errors which cannot be recovered within 63 retries and ECC correction should not exceed 10 per 10^{17} bits read.

(2) Positioning error rate

Positioning errors which can be recovered by one retry should be 10 or less per 10^{8} seeks.

2.1.5 Reliability

(1) Mean Time to Failures (MTTF)

MTTF of the HDDs during its life time is 2,000,000 hours (operating: 24 hours/day, 7 days/week average enclosure surface temperature: 50°C or less). Continual or sustained operation at case enclosure surface temperature above 50°C may degrade product reliability.

Note:

The MTTF is defined as:

$$\text{MTTF} = \frac{\text{Operating time (hours) at all field sites}}{\text{The number of equipment failures from all field sites}}$$

Failure of the equipment means failure that requires repair, adjustments, or replacement. Mishandling by the operator, failures due to bad environmental conditions, power trouble, host system trouble, cable failures, or other failures not caused by the equipment are not considered.

(2) Mean Time To Repair (MTTR)

MTTR is the average time taken by a well-trained service mechanic to diagnose and repair an HDD malfunction. The HDD is designed for a MTTR of 30 minutes or less.

(3) Service life

The service life under suitable conditions and treatment is as follows.

The service life is depending on the environment temperature. Therefore, the user must design the system cabinet so that the average enclosure surface temperature is as low as possible.

• Enclosure surface temperature:	from 5°C to 40°C	5 years
• Enclosure surface temperature:	more than 40°C to 45°C	4.5 years
• Enclosure surface temperature:	more than 45°C to 50°C	4 years
• Enclosure surface temperature:	more than 50°C to 55°C	3.5 years
• Enclosure surface temperature:	more than 55°C to 60°C	3 years
• Enclosure surface temperature:	more than 60°C or less than 5°C	No guarantee

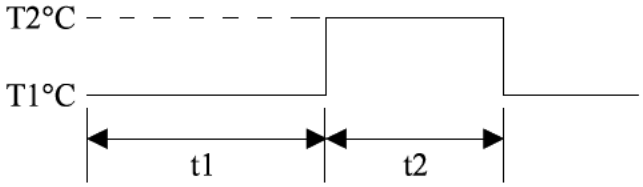
(Keep the enclosure surface temperature from 5°C to 60°C.)

Even if the HDDs are used intermittently, the longest service life is 5 years.

The maximum storage period without turning the power on is six months.

Note:

The "average enclosure surface temperature" means the average temperature at the enclosure surface throughout the year when the HDDs are operating.



$$\text{Average DE surface temperature} = \frac{T1 \times t1 + T2 \times t2}{t1 + t2}$$

(4) Data security at power failure

Integrity of the data on the disk is guaranteed against all forms of DC power failure except on blocks where a write operation is being performed. The above does not applied to formatting disks or assigning alternate blocks.

2.1.6 Load/Unload

Be sure to issue and complete the following commands for unloading before cutting off the power supply.

600,000 times of normal Load /Unload can be performed by a command and power management.

Unload is executed by the following commands:

- START STOP UNIT

Load/unload is also executed as one of the idle modes of the drive.If power is removed from the drive while the heads are over the media an Emergency Unload will take place. An Emergency Unload is performed by routing the back-EMF of the spindle motor to the actuator voice coil. An Emergency Unload is mechanically much more stressful to this drive than a controlled Unload. The minimum number of Emergency Unloads that can be successfully performed is 50,000. Emergency Unload should only be performed when it is not possible to perform a controlled Unload.

CHAPTER 3 Data Format

This chapter explains data space definition, logical data block addressing, and defect management on the HDDs.

3.1 Data Space

The HDDs manage the entire data storage area divided into the following three data spaces.

- User space: Storage area for user data
- Internal test space: Reserved area for diagnostic purposes
- System space: Area for exclusive use of HDDs themselves

The user space allows a user access by specifying data. The user space can be accessed with the logical data block addressing method described in Section 3.2. The internal test space is used by Read/write test of self-diagnostics test, but user can't use direct access. The system space is accessed inside the HDDs at power-on or during the execution of a specific command, but the user cannot directly access the system space.

3.1.1 Cylinder Configuration

The HDDs allocate cylinders to the user space, Internal test space, and system space. Figure 3.1 shows the cylinder configuration.

Spare areas (alternate areas) for defective sectors are provided in the user space. See Subsection 3.1.2 for details.

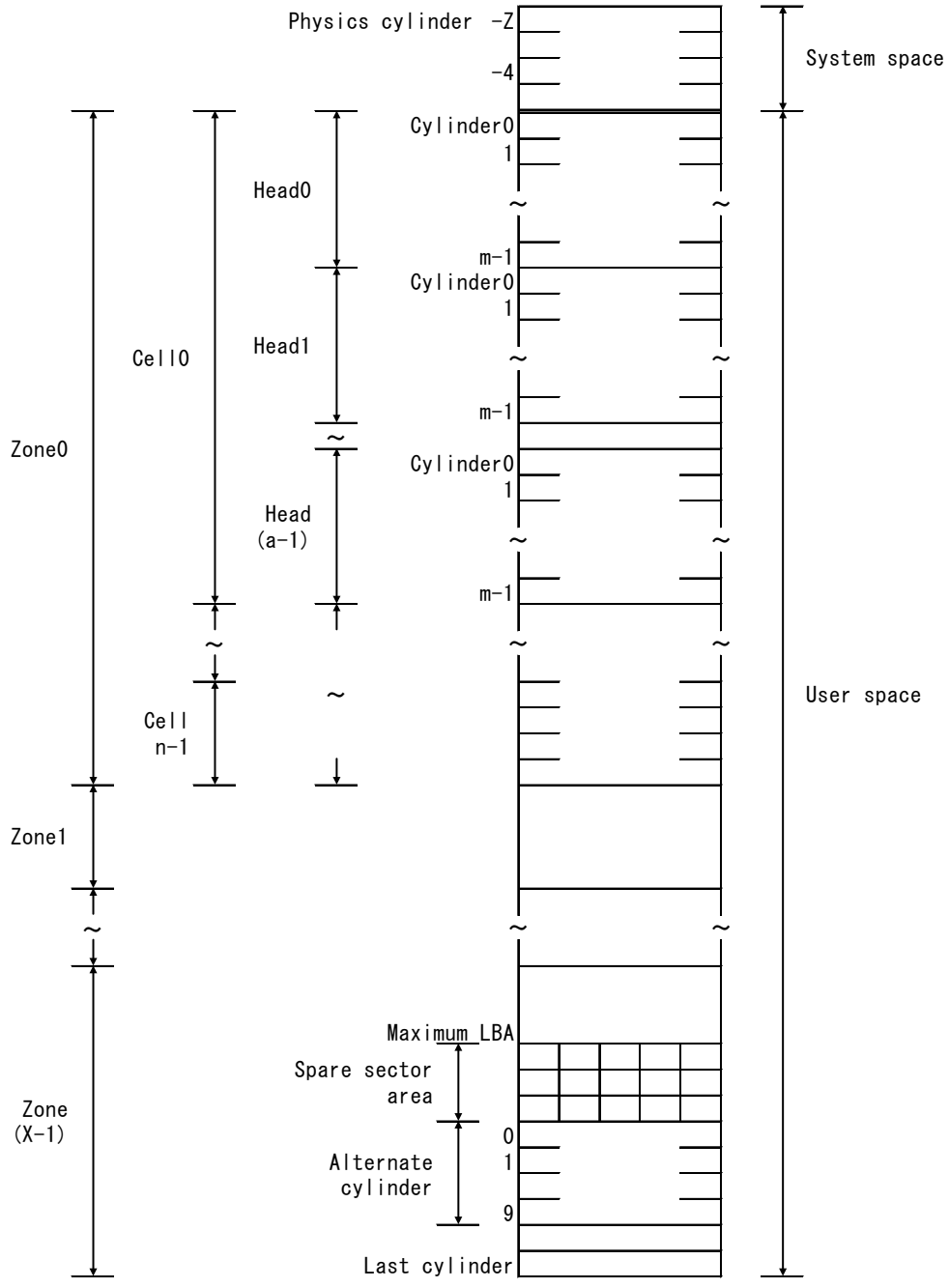


Figure 3.1 Cylinder configuration

Apart from the above logical configuration, the HDDs intend to increase the storage capacity by dividing all cylinders into several zones and changing a recording density of each zone.

(1) User space

The user space is a storage area for user data. The data format on the user space (the length of data block and the number of data blocks) can be specified with the MODE SELECT command.

The user can also specify the number of logical data blocks to be placed in the user space with the MODE SELECT command. When the number of logical data blocks is specified, as many cylinders as required to place the specified data blocks are allocated in the user space.

Always 10 cylinders are located at the end of the last zone in the user space as an alternate cylinder. Alternate cylinders will be used for alternate blocks. See Subsections 3.1.2 and 3.3.2 for details.

(2) Internal test space

The Internal test space is an area for diagnostic purposes only and its data block length is always 512Byte. The Internal test space consists of 8 cylinders and outer-most cylinder is always assigned. The user cannot change the number of cylinders in the Internal test space or their positions.

(3) System space

The system space is an area for exclusive use of the HDDs itself and the following information are recorded.

- Defect list (P list and G list)
- MODE SELECT parameter (saved value)
- Statistical information (log data)
- Controller control information

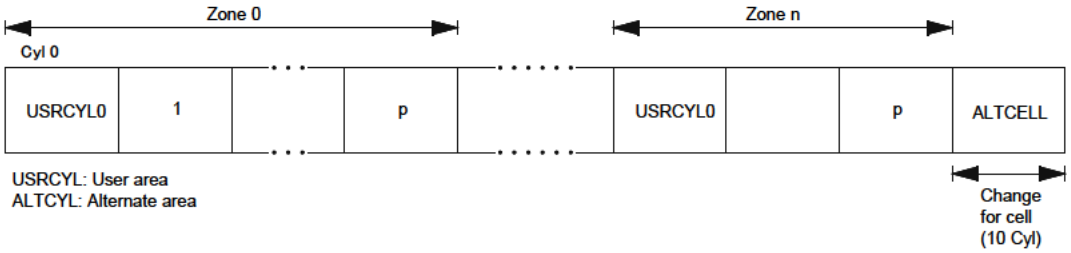
The above information is duplicated in several different locations for safety.

Note:

The system space is also called SA area.

3.1.2 Alternate Spare Area

The alternate cylinder is used for replacement action via the REASSIGN BLOCKS command or automatic replacement processing. The alternate cylinder is allocated to 10 cylinders at the end of the last zone in the user space.



Note: The number of alternate cylinders cannot be changed.

Figure 3.2 Alternate cylinder

3.1.3 Track Format

(1) Physical sector allocation

Figure 3.3 shows the allocation of the physical sectors in a track. The length in bytes of each physical sector and the number of sectors per track vary depending on the logical data block length. The unused area (G4) exists at the end of the track in formats with most logical data block lengths.

The interval of the sector pulse (length of the physical sector) is decided by the HDDs internal free running clock frequency. This clock is not equal to the interval of the byte clock for each zone. Therefore, the physical sector length cannot be described with a byte length.

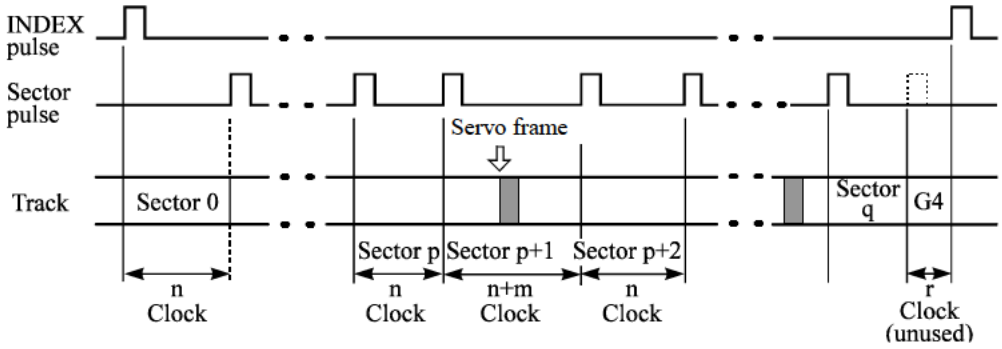


Figure 3.3 Track format

(2) Track skew and head skew

To avoid waiting for one turn involved in head and cylinder switching, the first logical data block in each track is shifted by the number of sectors (track skew and head skew) corresponding to the switching time. Figure 3.4 shows how the data block is allocated in each track.

At the cylinder switching location in a head, the first logical data block in track t + 1 is allocated at the sector position which locates the track skew behind the sector position of the last logical data block sector in track t.

At the head switching location, like the cylinder switching location, the first logical data block in a cylinder is allocated at the sector position which locates the head skew behind the last logical sector position in the preceding cylinder.

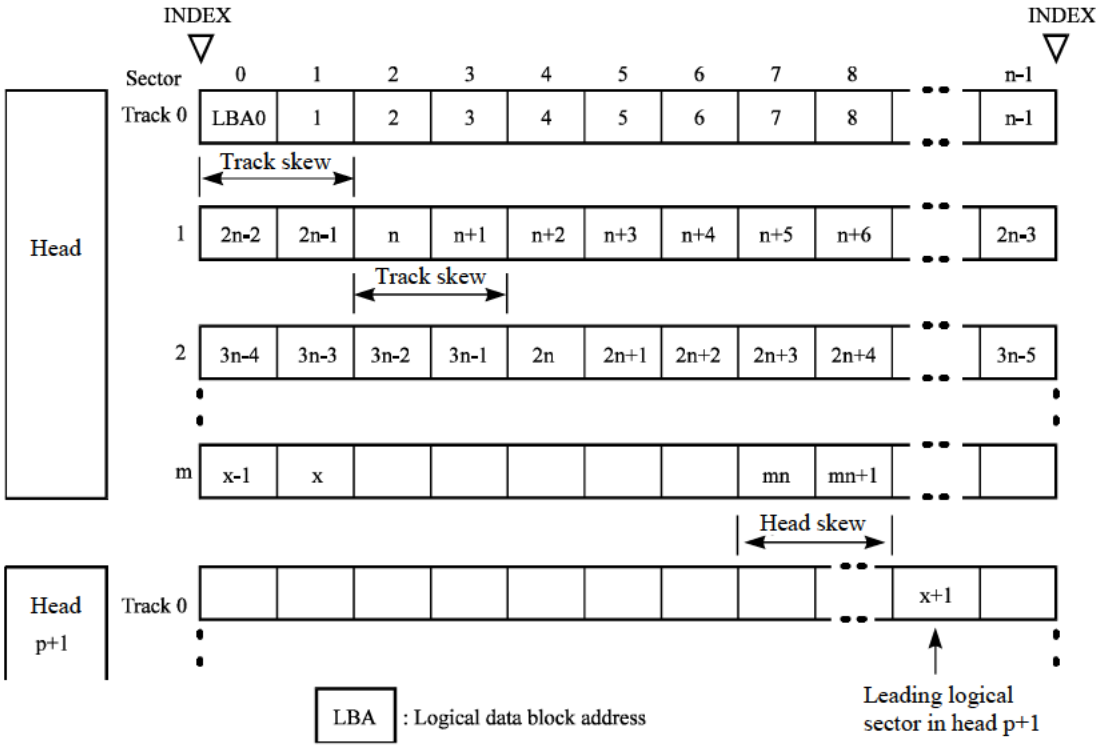


Figure 3.4 Track skew/head skew

The number of physical sectors (track skew factor and head skew factor) corresponding to the skew time varies depending on the logical data block length because the track skew and the head skew are managed for individual sectors. The HDD automatically determine appropriate values for the track skew factor and the head skew factor according to the specified logical data block length.

3.1.4 Sector Format

Each sector on the track consists of an ID field, a data field, and a gap field which separates them. Figure 3.5 gives sector format examples.

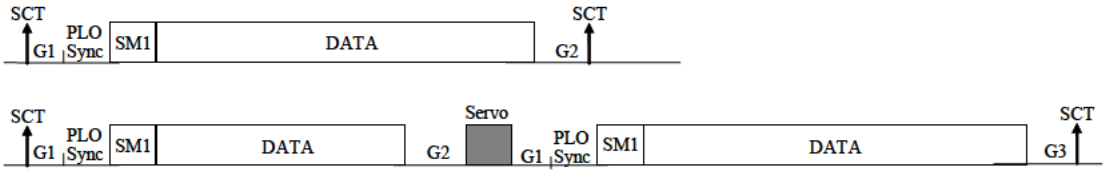


Figure 3.5 Sector format

Each sector on the track consists of the following fields:

(1) Gaps (G1, G2, G3)

No pattern is written on the gap field.

(2) PLO Sync

In this field, pattern X'00' is written.

(3) Sync Mark (SM1)

In this field, special pattern is written. This special pattern indicates the beginning of the data field.

(4) Data field (DATA)

Encoded data is stored in the data field of the sector. This length is composed of the logical data block, BCRC and MCRC. The logical data is specified with a parameter in the MODE SELECT command.

3.1.5 Format Capacity

The size of the usable area for storing user data on the HDD (format capacity) varies according to the logical data block or the size of the spare sector area. Table 3.1 lists examples of the format capacity when the typical logical data block length and the default spare area are used. The following is the general formula to calculate the format capacity.

The following formula must be used when the number of logical data blocks is specified with the parameter in the MODE SELECT command.

[Format capacity] = [logical data block length] × [number of logical data blocks]

The logical data block length, the maximum logical block address, and the number of the logical data blocks can be read out by a READ CAPACITY, MODE SENSE command after initializing the disk.

Table 3.1 Format capacity

Model number	Data block length (byte)	User blocks	Format capacity
AL14SEB/SEQ120N	512	2,344,225,968	1200 GB (*1)
AL14SEB/SEQ090N		1,758,174,768	900 GB (*1)
AL14SEB/SEQ060N		1,172,123,568	600 GB (*1)
AL14SEB/SEQ045N		879,097,968	450 GB (*1)
AL14SEB/SEQ030N		585,937,500	300 GB (*1)

(*1) One gigabyte (GB) = one billion bytes; accessible capacity will be less and actual capacity depends on the operating environment and formatting.

Note:

Total number of spare sectors is calculated by adding the number of spare sectors in each primary cylinder and the number of sectors in the alternate cylinders.

3.2 Logical Data Block Addressing

The HDDs relate a logical data block address to each physical sector at formatting. Data on the disk is accessed in logical data block units. The initiator specifies the data to be accessed using the logical data block address of that data.

(1) Block address of user space

The logical data block address number is consecutively assigned to all of the data blocks in the user space starting with 0 to the first data block.

The HDDs treat sector 0, track 0, cylinder 0 as the first logical data block. The data block is allocated in ascending order of addresses in the following sequence (refer to Figure 3.5):

1) Logical data blocks are assigned in ascending order of sector number in the same track.

2) Subsequent logical data blocks are assigned in ascending order of track number in the same head. Within the same track, logical data blocks are assigned in the same way as step 1).

3) Subsequent logical data blocks are assigned to sectors in every track in the same cell. Within the same track, logical data blocks are assigned in the same way as step 1) and 2).

4) After blocks have been assigned in the same cell according to steps 1) to 3), subsequent logical data blocks are assigned in ascending order of cell number in the same way as in steps 1) to 3). Logical data blocks are assigned starting from track 0 in the next cell until the last cylinder (immediately preceding the alternate cylinder n-1 shown in Figure 3.1).

When the logical data block is allocated, some sectors (track skew and head skew) shown in Figure 3.4 are provided to avoid waiting for one turn involving head and cylinder switching at the location where the track or the head is physically switched.
See Subsection 3.3.2 for defective/alternate block treatment and the logical data block allocation method in case of defective sectors exist on the disk.

(2) Alternate area

Alternate areas in the user space (spare sectors in the HDD and alternate cylinders) are not included in the above logical data block addresses. Access to sectors which are allocated as an alternate block in the alternate area is made automatically by means of the HDD sector slip treatment or alternate block treatment (explained in Subsection 3.3.2), so the user does not have to worry about accessing the alternate area. The user cannot access with specifying the data block on the alternate area explicitly.

3.3 Defect Management

3.3.1 Defect List

Information of the defect location on the disk is managed by the defect list. The following are defect lists which the HDDs manage.

- P list (Primary defect list): This list consists of defect location information available at the HDD shipment and is recorded in a system space. The defects in this list are permanent, so the initiator must execute the alternate block allocation using this list when initializing the disk.

- D list (Data defect list): This list consists of defect location information specified in a FORMAT UNIT command by the initiator at the initialization of the disk. This information is recorded in the system space of the HDD as the G list. To execute the alternate block allocation, the FORMAT UNIT command must be specified.

- G list (Growth defect list): This list consists of defective logical data block location information specified in a REASSIGN BLOCKS command by the initiator, information on defective logical data blocks assigned alternate blocks by means of the HDD automatic alternate block allocation and information specified as the D list. They are recorded in the system space on the HDD.

The initiator can read out the contents of the P and G lists by the READ DEFECT DATA command.

3.3.2 Alternate Block Allocation

The alternate data block is allocated to a defective data block (= sectors) in defective sector units by means of the defect management method inside the HDDs. The initiator can access all logical data blocks in the user space, as long as there is no error.

Spare sectors to which alternate blocks are allocated can be provided in "alternate cylinders". See Subsection 3.2 for details.

Both of the following are applicable to the alternate block allocation.

- Sector slip treatment: Defective sectors are skipped and the logical data block corresponding to those sectors is allocated to the next physical sectors.

- Alternate sector treatment: The logical data block corresponding to defective sectors is allocated to unused spare sectors in the alternate cylinder.

The alternate block allocation is executed by the FORMAT UNIT command, the REASSIGN BLOCKS command, or the automatic alternate block allocation. Refer to Subsection 6.3.2 "Auto alternate block allocation processing" of the SAS INTERFACE SPECIFICATION for details of specifications on these commands. The logical data block is allocated to the next physically continued sectors after the above sector slip treatment is made. On the other hand, the logical data block is allocated to spare sectors which are not physically consecutive to the adjacent logical data blocks. If a command which processes several logical data blocks is specified, the HDD processes those blocks in ascending order of logical data block.

(1) Alternate block allocation during FORMAT UNIT command execution

During FORMAT UNIT command execution, defective sectors registered in defect lists (P, G, or E) are reallocated by slipping sector until spare sectors in the cell are all used up. When they are used up, unused spare sectors in the alternate cylinder are allocated to the defective sectors that follow the sector by means of alternate sector treatment. Figure 3.6 is examples of the alternate block allocation during the FORMAT UNIT command execution.

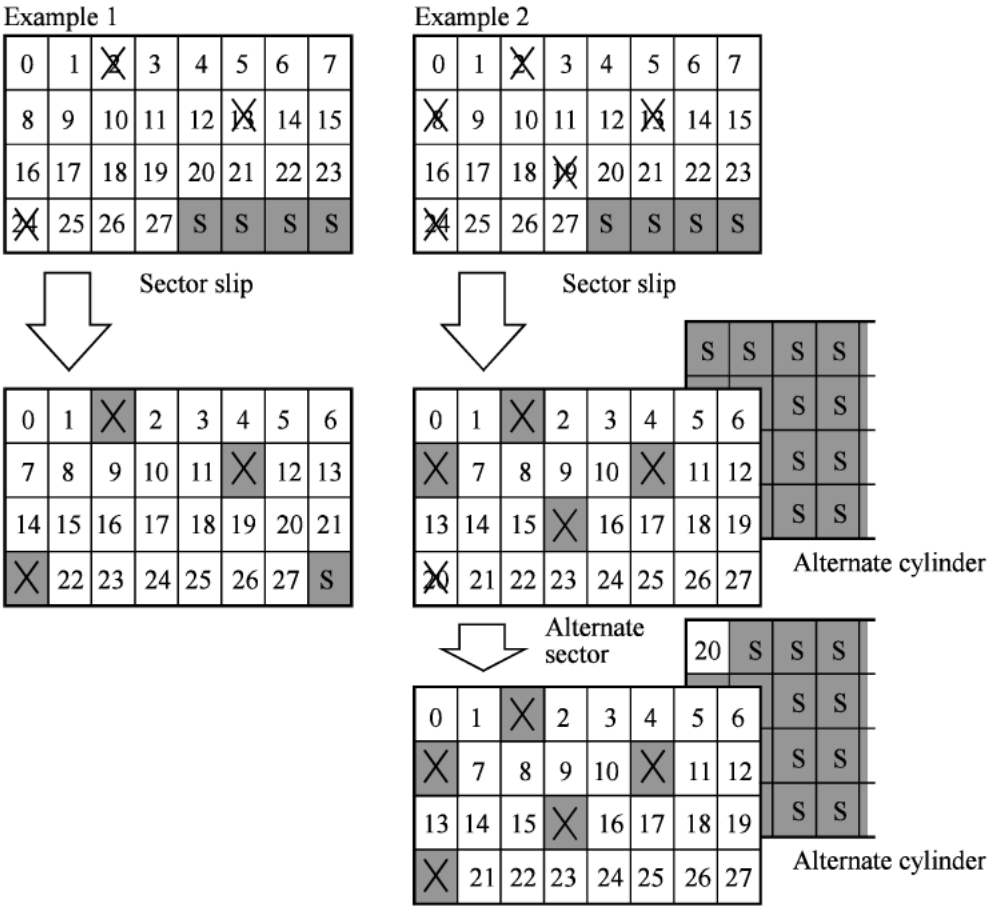


Figure 3.6 Alternate block allocation by FORMAT UNIT command

During FORMAT UNIT command, alternate block allocation is conducted in following cases:

1) Unrecovered write offtrack condition during a media write
2) Uncorrectable Data Error during a media read (certification) *1

If above errors are detected during FORMAT UNIT command, the HDDs allocate the alternate block(s) to the defective data blocks. Reassign procedure itself is the same as one in REASSIGN BLOCKS command.

*1 Certification is permitted when DCRT flag is cleared (DCRT flag=0) in FORMAT UNIT command.
The HDDs check all initialized logical data blocks by reading them out after the above alternate block allocation is made to initialize (format) the disk.

(2) Alternate block allocation by REASSIGN BLOCKS command

When the REASSIGN BLOCKS command is specified, the alternate block is allocated to the defective logical data block specified by the initiator by means of alternate sector treatment. The alternate block is allocated to unused spare sectors in the alternate cylinder.

Figure 3.7 is examples of the alternate block allocation by the REASSIGN BLOCKS command.

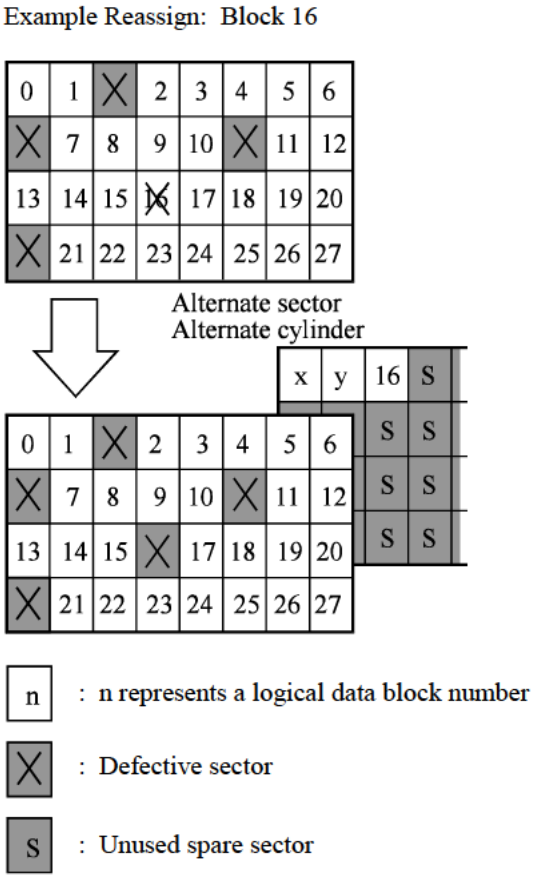


Figure 3.7 Alternate block allocation by REASSIGN BLOCKS command

(3) Automatic alternate block allocation

- Automatic alternate block allocation at read operation

If the ARRE flag in the MODE SELECT parameter permits the automatic alternate block allocation, the HDDs automatically execute the alternate block allocation and data duplication on the defective data block detected during the READ command. This allocation method is the same as with the REASSIGN BLOCKS command (alternate sector treatment).

- Automatic alternate block allocation at write operation

If AWRE flag in the MODE SELECT parameter permits the automatic alternate block allocation, the HDDs execute two kinds of automatic alternate processing during WRITE command processing as described below:

Type 1 (Reassignment of Uncorrectable Read Error sector)

1) Commands to be applied
   - WRITE
   - WRITE at executing WRITE AND VERIFY
2) Application requirements
   When any of the above commands is issued to LBA registered in the uncorrectable error log of the READ command (LBA log of uncorrectable error while the READ command is executed), the AWRE processing is applied.
3) AWRE processing
   The following processings are performed when the LBA matches the one in the uncorrectable error log:
   a) Primary media check
      - Creates an uncorrectable error pattern (invalid LBA pattern) in the position of the error LBA, repeats the primary media check up to three times. If the error still occurs after the check repeated three times, it is judged to be defective. Then, it performs the alternate processing.
   b) Alternate processing
      - Alternate media check
        Writes the data that causes an unrecoverable error into the alternate block, and performs the media check.
        (If the alternate block is a defective sector, the block is registered to the G list, another alternate block is allocated.)
   c) SA and defect map update processing (on alternate side)

When an error occurs in the alternate processing, this WRITE command terminates with error.

When the alternate processing normally terminates, the WRITE command is executed.

Type 2 (Reassignment of write fail sector)

1) Commands to be applied
   - WRITE
   - FORMAT UNIT
   - WRITE at executing WRITE AND VERIFY
2) Application requirements / processing

   When WRITE command detects any Servo error (e.g. Write offtrack error) and cannot be recovered within pre-determined retry number (specified in Mode Parameter). For the sectors around defective Servo, alternate blocks are allocated and the data of this WRITE commands are re-written.

   Sectors to be made AWRE shall be following:
   - the sector where the error occurs and the latter sectors and,
   - the sectors whose data are logically continual and stored in Cache,
   - the sectors which will be processed in this Write command and,
   - the sectors which locate between erroneous Servo -1 and +1 (including Split sector)

   This function is also applied for the sector that has already been re-assigned.

Remark:

When a write protection is prohibited through the setting terminal, the auto alternate block allocation processing specification is disabled.

IMPORTANT

Automatic alternate block allocation is made up to the following quantities during the execution of one command:

ARRE = Twice

AWRE (Type 1) = 16 times

AWRE (Type 2) = Maximum number which can be processed within the recovery time limit

If more than the above mentioned defective block is detected, the alternate block assignment processing for the first defective block is executed but the alternate block assignment processing for the second one is not executed and the command being executed terminates. However, the initiator can recover the twice error by issuing the same command again.

When an error is detected in a data block in the data area, recovery data is rewritten and verified in automatic alternate block allocation during the execution of the READ command. Alternate block allocation will not be made for the data block if recovery is successful.

Example: Even if the data error which is recoverable by the WRITE LONG command is simulated, automatic alternate block allocation will not be made for the data block.

3.4 MODE SELECT Parameter : Pages 3, 4

Table 3.2 lists details of each parameter value on pages 3, 4, and C.
(Note that the specifications stated here may be revised without prior notice.)

Table 3.2 Details of parameters on MODE SELECT parameter: pages 3, 4

Page	Byte		AL14SEB /SEQ120N	AL14SEB /SEQ090N	AL14SEB /SEQ060N	AL14SEB /SEQ045N	AL14SEB /SEQ030N
			Sector = 512 Bytes				
3	2-3	Number of tracks per zone	0x01B8	0x014A	0x0DC	0x00A5	0x006E
	4-5	Number of alternate sectors per zone	0x0000				
	8-9	Number of alternate tracks per zone	0x0050	0x003C	0x0028	0x001E	0x0014
	10-11	Number of sectors per track	0x0946				
4	2-4	Number of cylinders	0x02554E				
	5	Number of heads	8	6	4	3	2

CHAPTER 4 Installation Requirements

This chapter describes the mounting, power supply, connection, and environmental requirements.

4.1 Mounting Requirements

4.1.1 Dimensions

Figure 4.1 show the dimensions of the HDDs and the location of the mounting screw holes.

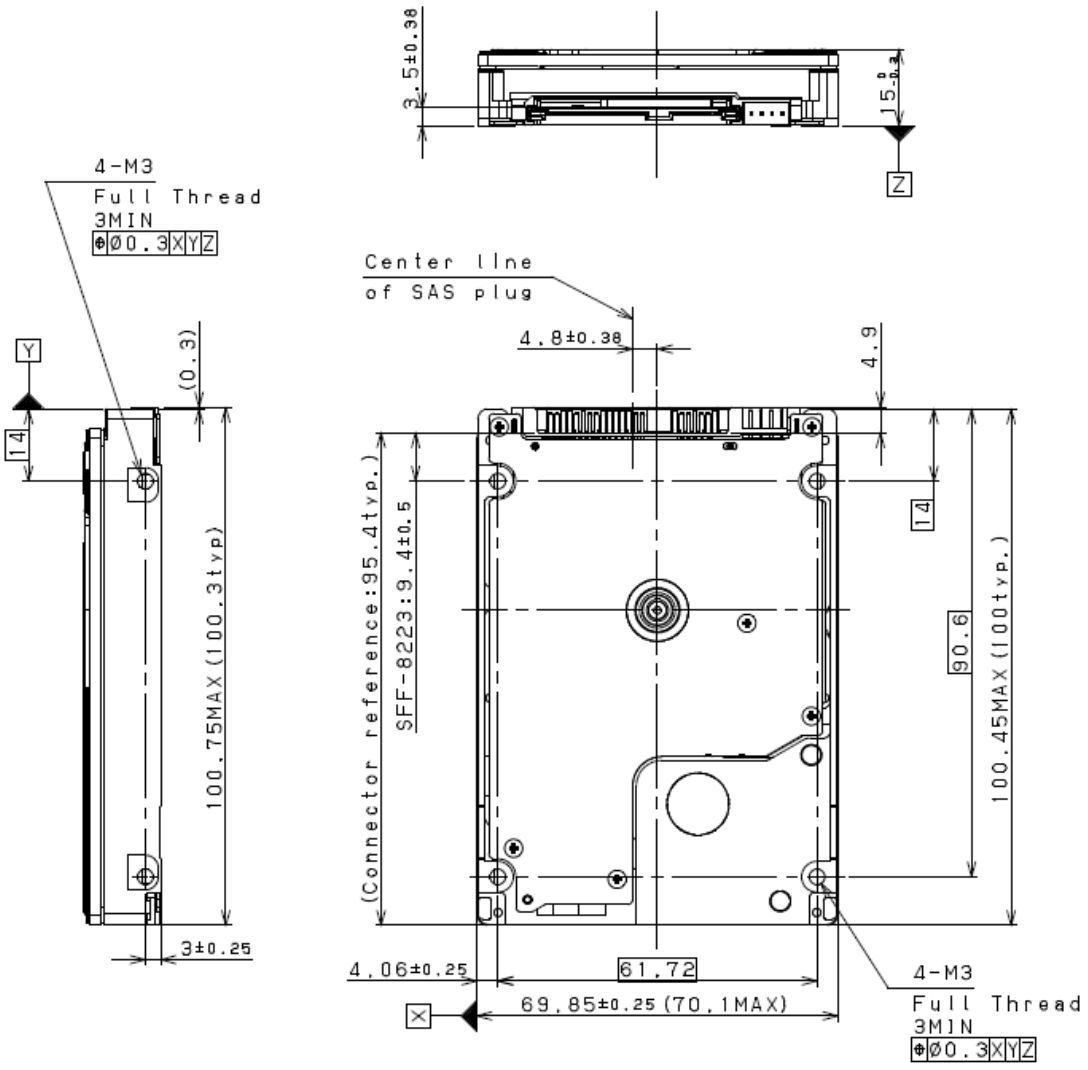


Figure 4.1 Dimensions

[Unit: mm]

4.1.2 Mounting Orientations

As shown in Figure 4.2, the HDD can be installed flat on any of its six sides. Inclination from a vertical or horizontal plane should not exceed 5°.

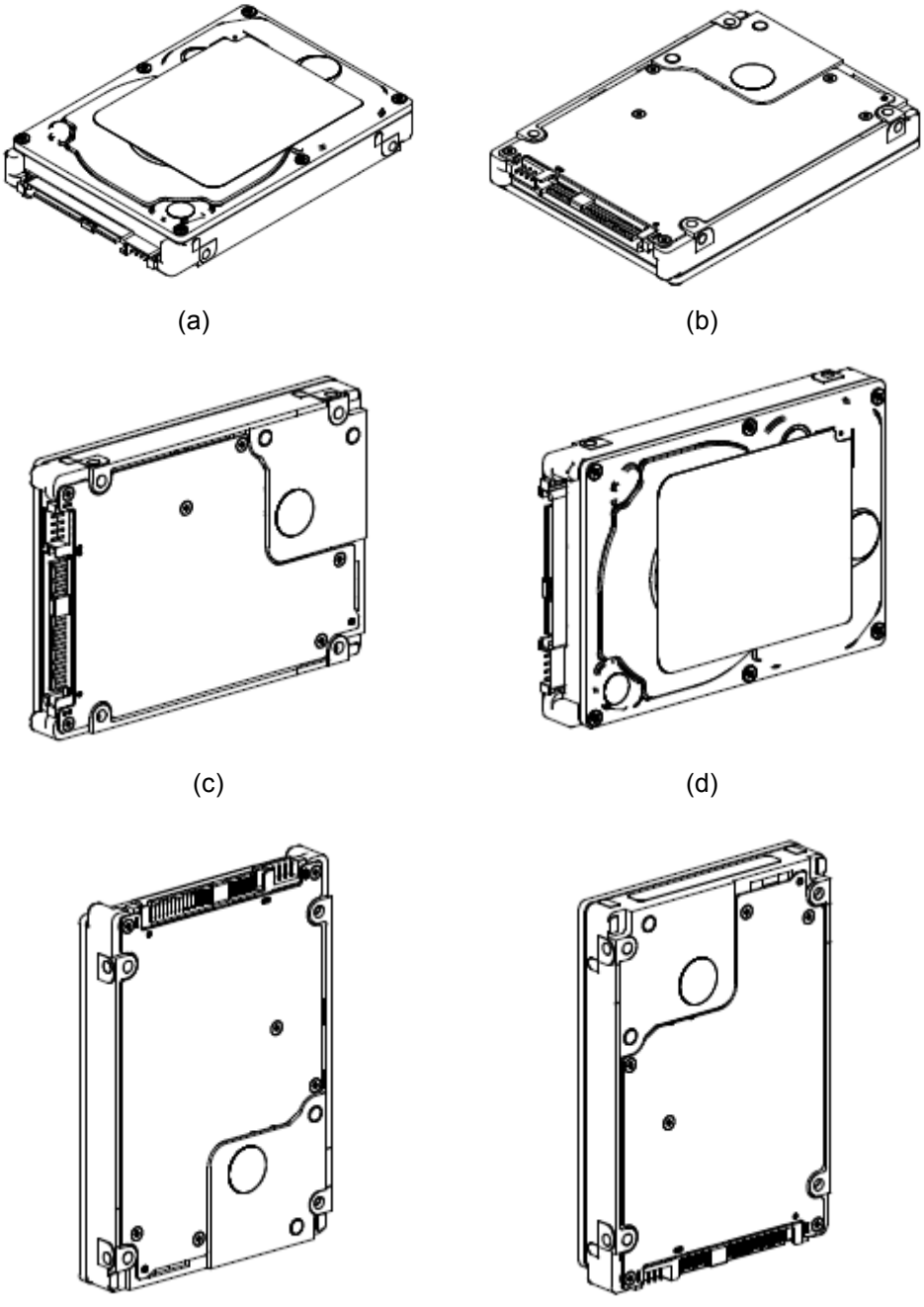


Figure 4.2 HDD orientations

4.1.3 Notes on Mounting

⚠CAUTION	
Prohibited	Damage Do not remove any labels from the HDD or deface the HDDs in any way. HDDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.

(1) Mounting screw

The mounting screws must use M3 × 0.5 metric

(2) Mounting frame structure

As for a system frame structure mounting the HDDs, the following attentions are required.

a) The frame shall not touch the PCBA of the HDDs. For example as shown in Figure 4.3, mount the HDDs with a gap of 2.5 mm or more from the frame.

b) As shown in Figure 4.3, the inward projection of the screw from the HDD frame wall at the corner must be 2.5 mm ±0.5 mm.

c) Tightening torque of screw must be secured with 0.49 N·m (5 kgf·cm) ±12%.

d) The frame must not distort the HDDs.

e) The impact by an electric screwdriver must not exceed the HDD specifications.

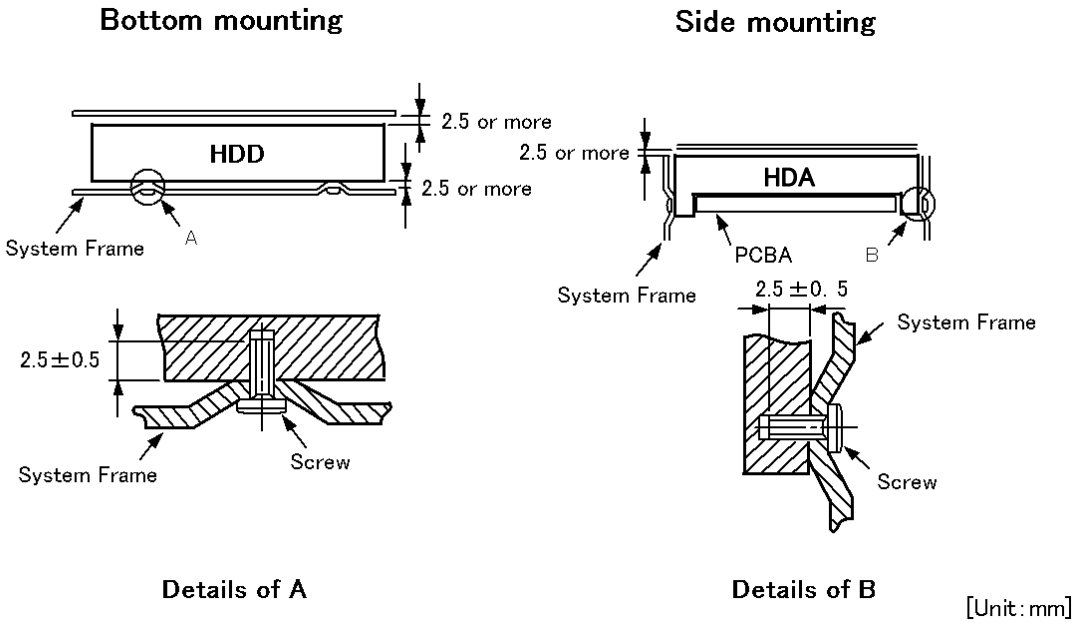


Figure 4.3 Mounting frame structure example

(3) Limitation of side-mounting

Use all 4 mounting holds on the both sides.

(4) Limitation of bottom-mounting

Use all 4 mounting holds on the bottom face.

(5) Breathing hole

Do not cover the breathing hole as shown in Figure 4.4.

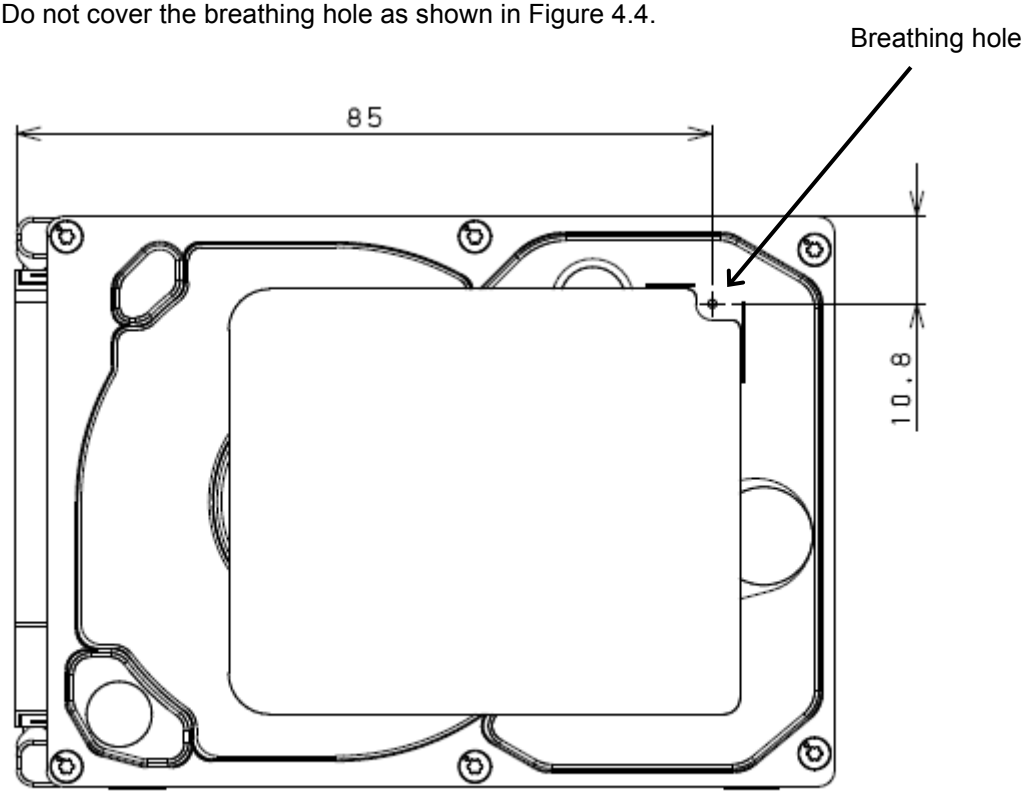


Figure 4.4 Breathing hole location

(6) Environmental temperature

Temperature condition at installed in a cabinet is indicated with ambient temperature measured 30 mm from the HDD. At designing the system cabinet, consider following points.

- Make a suitable air flow so that the enclosure surface temperature never exceeds 60°C.
- Cool the PCBA side especially with air circulation inside the cabinet. Confirm the cooling effect by measuring the surface temperature of the PCBA and the HDA. These measurement results must satisfy the temperature condition listed in Table 4.1.
- Keep the enclosure surface temperature at 50°C or below to meet the condition for assuring an MTBF of 2,000,000 hours. An air flow of 0.5m/s or more is required at ambient temperature 30°C.

Table 4.1 Surface temperature check point and maximum temperature

Measurement point	Max. temperature
1 (Enclosure surface)	60°C
2 (PCBA surface)	91°C
3 (PCBA surface)	92°C

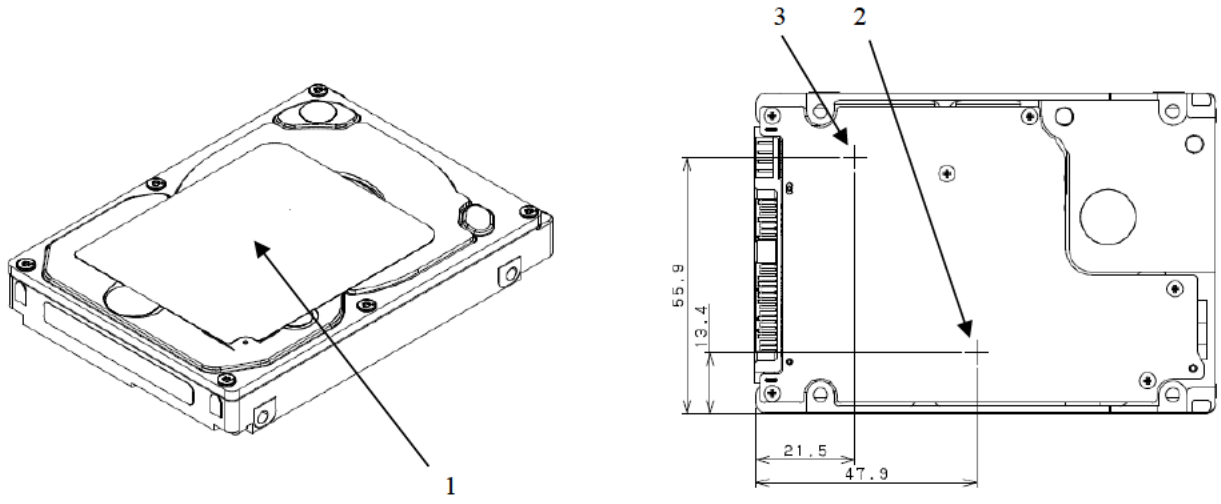


Figure 4.5 Surface temperature measurement points

(7) Environmental magnetic field

Do not install the HDDs in the vicinity of equipment giving off strong magnetic fields, such as monitors, televisions, or loudspeakers.

(8) Leakage magnetic flux

Do not mount the HDDs near the devices which may be affected by leakage magnetic.

4.2 Power Supply Requirements

(1) Allowable input voltage and current

The power supply input voltage measured at the power supply connector pin of the HDDs (receiving end) must satisfy the requirement given in Subsection 2.1.3. (For other requirements, see Items (4) below.)

(2) Current waveform (reference)

Figure 4.6 shows the spin-up current waveform of +5V DC and +12V DC.

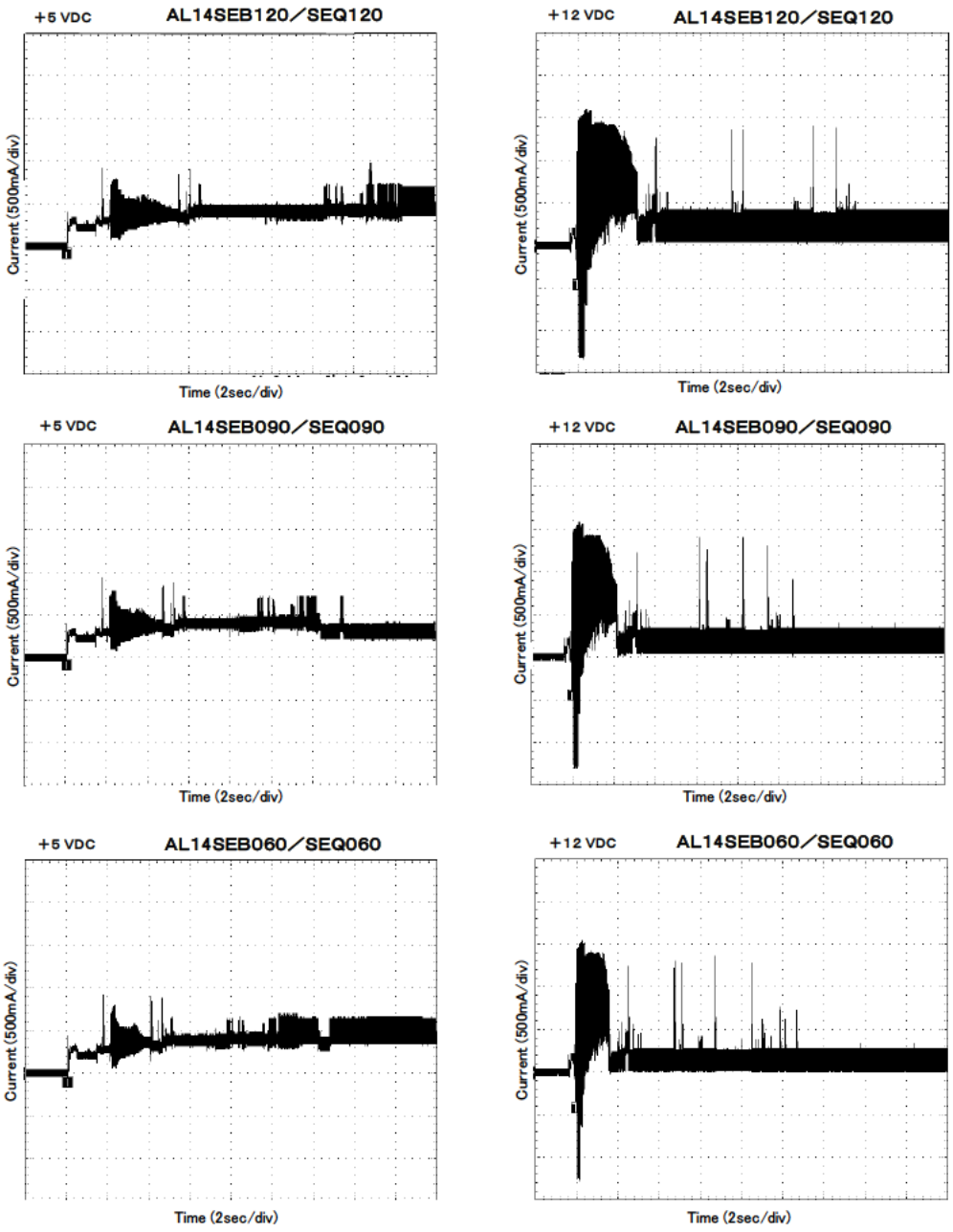


Figure 4.6 Current waveform (Spin-up) (1/2)

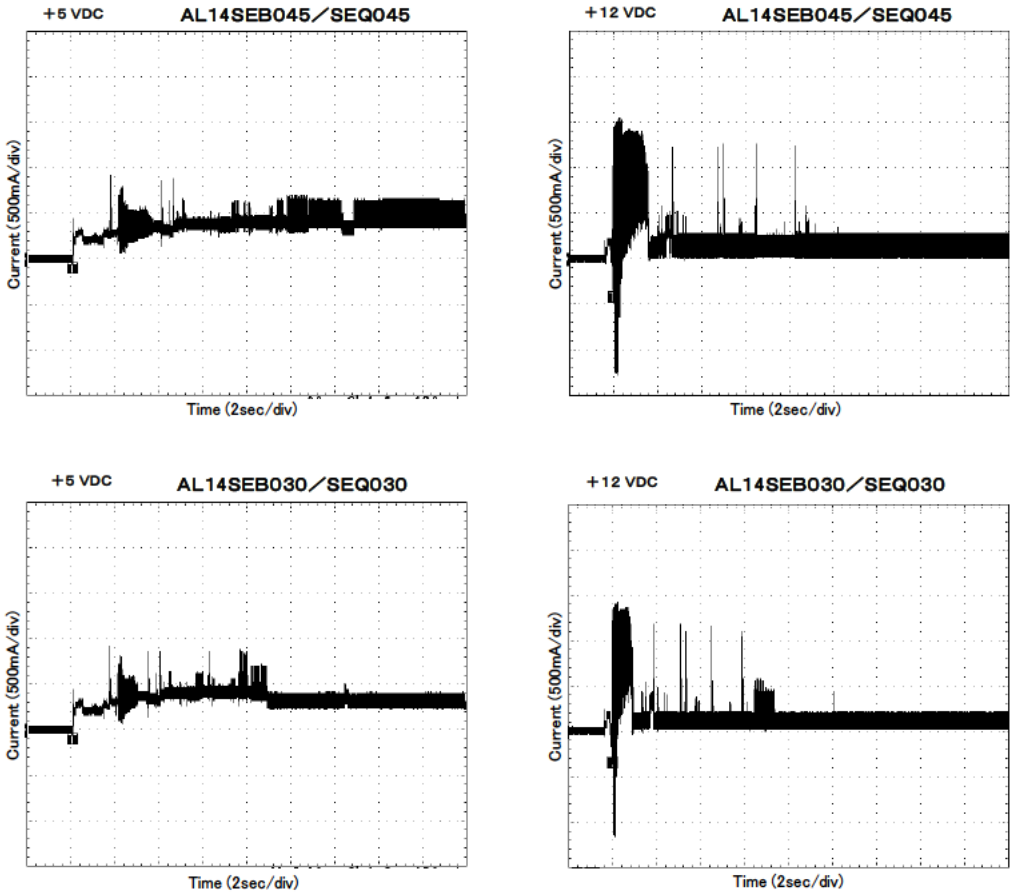


Figure 4.6 Current waveform (Spin-up) (2/2)

Figure 4.7 Shows the maximum seek current waveform of +5V DC and +12V DC.

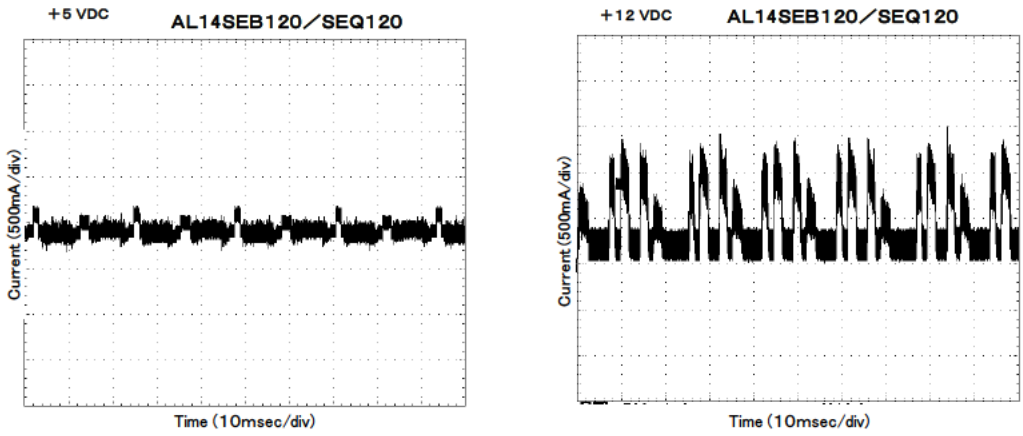


Figure 4.7 Current waveform (Max seek) (1/2)

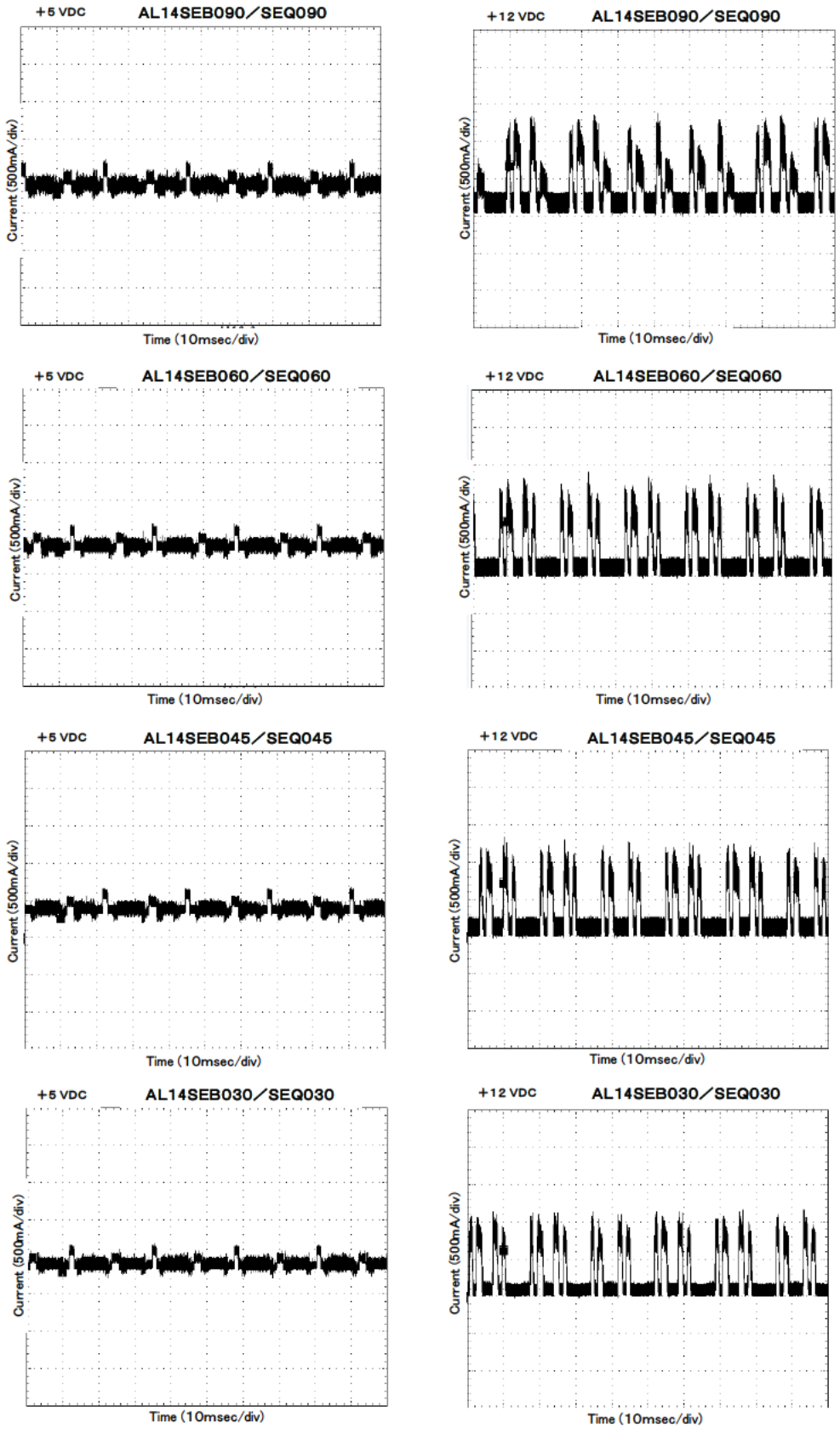


Figure 4.7 Current waveform (Max seek) (2/2)

(3) Power on/off sequence

The order of the power on/off sequence of +5V DC and +12V DC, supplied to the HDDs, does not matter.

(4) Sequential starting of spindle motors

After power is turned on to the HDDs, a large amount of current flows in the +12V DC line when the spindle motor rotation starts. Therefore, if more than one HDD are the spindle motors should be started sequentially using one of the following procedures to prevent overload of the power supply unit.

a) Control the sending of the NOTIFY (ENABLE SPINUP) primitives in intervals of 12 seconds or more so that the spindle motors of individual HDDs are started sequentially.

b) Turn on the +12V DC power in the power supply unit at intervals of 12 seconds or more to start the spindle motors sequentially.

(5) Noise filter

To eliminate AC line noise, a noise filter should be installed at the AC input terminal on the HDD power supply unit. The specification of this noise filter is as follows:

- Attenuation: 40 dB or more at 10 MHz
- Circuit construction: T-configuration as shown in Figure 4.8 is recommended.

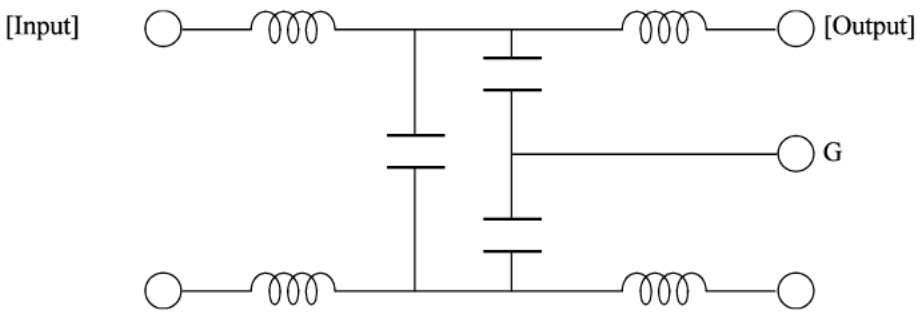


Figure 4.8 AC noise filter (recommended)

4.3 Connection Requirements

4.3.1 Connector Location

Figure 4.9 shows a location of the interface connector.

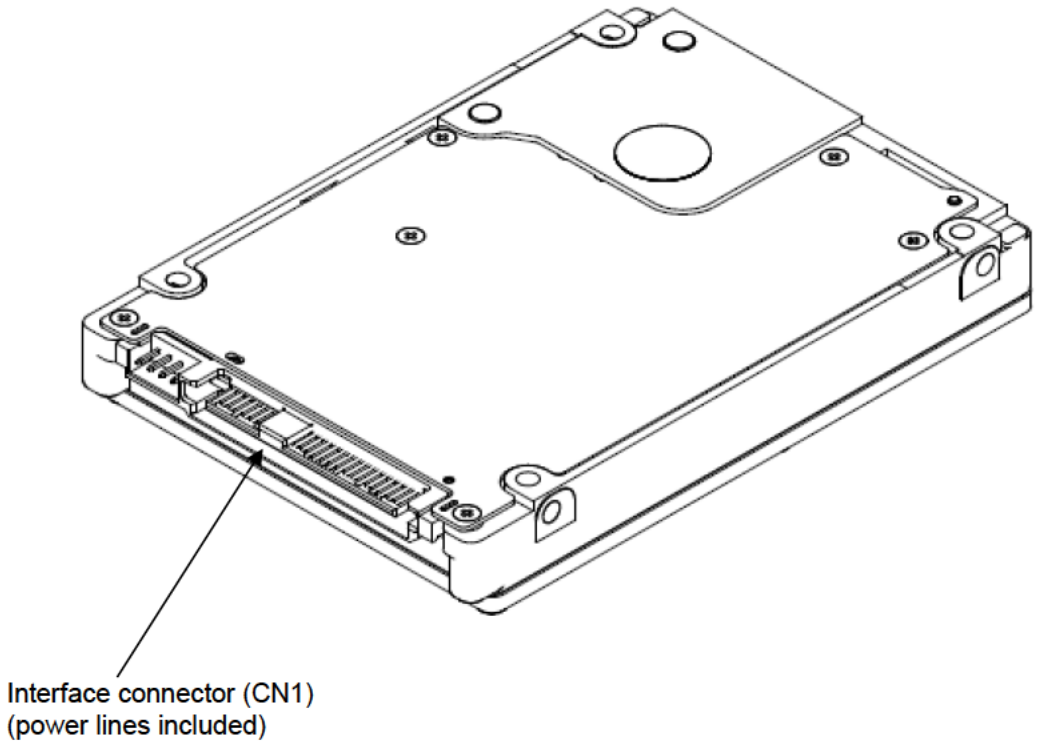


Figure 4.9 Connector location

4.3.2 Interface Connector

Figure 4.10 shows the SAS type interface connector (SAS plug) overview.

Table 4.2 lists the signal allocation of the SAS plug on the HDDs.

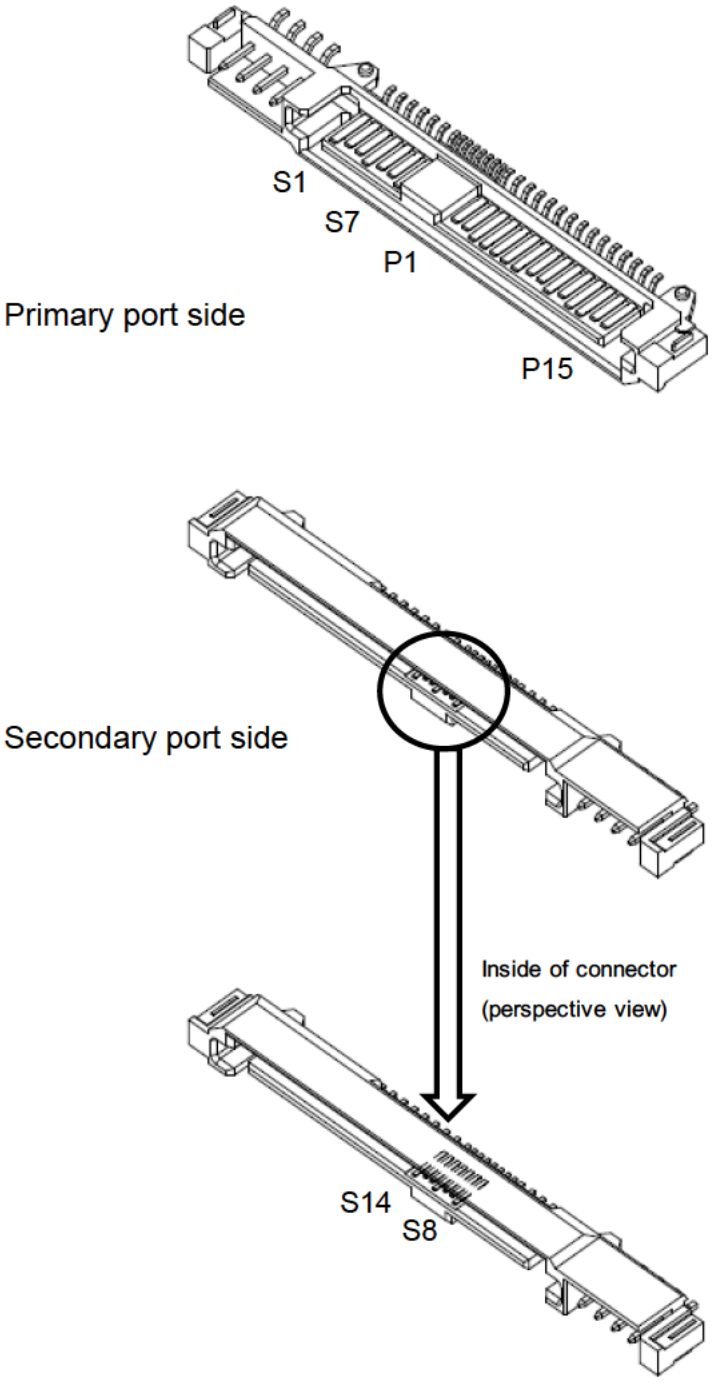


Figure 4.10 SAS plug connector overview

Table 4.2 Interface connector (SAS plug) signal allocation:CN1

Pin No.	Signal	Description
S1	GND	GND for SAS Primary Port
S2	RP+	SAS Primary Port Receive (positive) signal
S3	RP-	SAS Primary Port Receive (negative) signal
S4	GND	GND for SAS Primary Port
S5	TP-	SAS Primary Port Transmit (negative) signal
S6	TP+	SAS Primary Port Transmit (positive) signal
S7	GND	GND for SAS Primary Port
S8	GND	GND for SAS Secondary Port
S9	RS+	SAS Secondary Port Receive (positive) signal
S10	RS-	SAS Secondary Port Receive (negative) signal
S11	GND	GND for SAS Secondary Port
S12	TS-	SAS Secondary Port Transmit (negative) signal
S13	TS+	SAS Secondary Port Transmit (positive) signal
S14	GND	GND for SAS Secondary Port
P1 (*1)	Reserved (not used)	Not used
P2 (*1)	Reserved (not used)	Not used
P3 (*2)	POWER DISABLE	Power Disable Control input signal
P4	GND	GROUND
P5	GND	GROUND
P6	GND	GROUND
P7	+5V-Charge	Pre-charge pin for +5V
P8	+5V	+5V power supply input
P9	+5V	+5V power supply input
P10	GND	GROUND
P11	READY LED	READY LED output
P12	GND	GROUND
P13	+12V-Charge	Pre-charge pin for +12V
P14	+12V	+12V power supply input
P15	+12V	+12V power supply input

(* 1) P1 to P2 are +3.3V power supply input and pre-charge signals, and not used on the AL14SEB/SEQ series.

(* 2) The terminal P3 is used as POWER DISABLE control signal in SAS-3. This terminal connects with the GROUND or is an OPENED thing on the host side when the POWER DISABLE function is not used.

4.3.3 Ready LED Output Signal

Figure 4.11 shows a recommended circuit for external LED connection to Ready LED output signal.

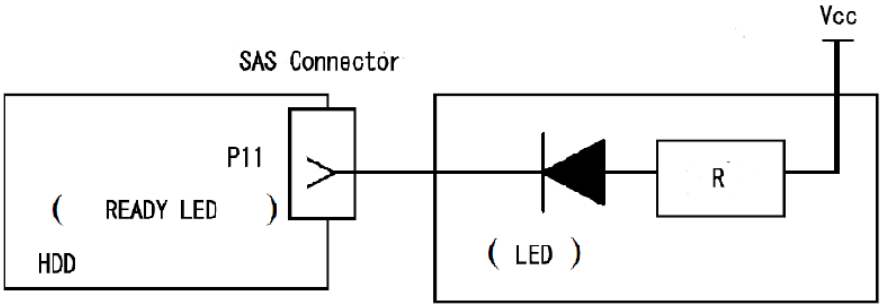


Figure 4.11 Recommended external circuit for Ready LED output

Either +3.3 V or +5 V can be used for external power supply for LED (Vcc). Current limiting resister (R) value need to be adjusted depend on the Vcc voltage. For +3.3 V Vcc voltage, recommended resistance is 220Ω. For +5 V Vcc voltage, recommended resistance is 330Ω.

	Minimum	Maximum
Absolute maximum Vcc voltage range	-0.5 V	5.25 V

4.3.4 Connector Requirements

Table 4.3 lists the recommended connectors for the host system.

Table 4.3 Recommended connectors

Manufacture	Part number	Remarks
Tyco Electronics AMP	1735104-1	Hybrid (SMT/Dip) type
	1735105-1	SMT type
	1735164-1	Press Fit Type
	1735234-1	Press Fit Type
Fujikura	SAS-RA29-S1AA-FG	Virtical SMT with Tab
	SAS-RC29-S1AA-FG	Virtical SMT with Lock pin
	SAS-RC29-S1AB-FG	Virtical SMT with Lock pin

4.3.5 POWER DISABLE Control input signal

When this signal is asserted at the High level, +5V/+12V power supply to the inside of the drive is cut with the switch in the HDDs. +5V/+12V power supply to the inside of the HDDs restarts when this signal is asserted at the Low level, and the drive begins the start processing according to the same procedure as turning on the power supply usually.

	Minimum	Maximum
Absolute maximum input voltage range	-0.5 V	3.6 V
Negated voltage (power on)	-0.5 V	0.7 V
Asserted voltage (power disabled)	2.1 V	3.6 V

CHAPTER 5 Installation

This chapter describes the notes on handling HDDs, setting, mounting HDDs, confirming HDD operations after installation and preparation for use, and dismounting HDDs.

5.1 Notes on Handling HDDs

The items listed in the specifications in Table 2.3 must be strictly observed.

(1) General notes

a) Do not give the HDD shocks or vibrations exceeding the value defined in the specifications because it may cause critical damage to the HDD. Especially be careful when unpacking.

b) Do not leave the HDD in a dirty or contaminated environment.

c) Since Electrostatic Discharge (ESD) may destroy the CMOS semiconductors in the HDD, note the following after unpacking:

- Use an antistatic mat and body grounding when handling the HDD.
- Hold the HDA when handling the HDD. Do not touch PCAs except for setting.

⚠CAUTION	
 **Instructions**	High temperature To prevent injury such as burn, do not touch the HDD while it is hot. The HDA and LSI become hot during operation and remain hot immediately after turning off the power.

(2) Unpackaging

a) Use a flat work area. Check that the "This Side Up" sign side is up. Handle the package on soft material such as a rubber mat, not on hard material such as a desk.

b) Be careful not to give excess pressure to the internal unit when removing cushions.

c) Be careful not to give excess pressure to the PCBA and interface connector when removing the HDD from the antistatic bag.

d) Do not remove any labels from the HDD. Never open the HDA for any reason.

(3) Installation/removal/replacement

a) Do not move the HDD when power is turned on or until the HDD completely stops (for 15 seconds) after power is turned off.

b) Place and keep removed screws and other parts where they will not get lost or damaged.

c) Keep a record of all maintenance work for replacing.

(4) Packaging

a) Store the HDD in the antistatic bag.

b) It is recommended to use the same cushions and packages as those at delivery. (For details, see Section 6.5.) If those at delivery cannot be used, use a package with shock absorption so that the HDD is free from direct shocks. In this case, fully protect the PCBA and interface connector so that they are not damaged.

(5) Delivery

a) When delivering the HDD, provide packaging and do not turn it over.

b) Minimize the delivery distance after unpacking and avoid shocks and vibrations with cushions. For the carrying direction at delivery, use one of the mount allowable directions in Subsection 4.1.2.

(6) Storage

a) Provide moistureproof packaging for storage.

b) The storage environment must satisfy the requirements specified in Subsection 2.1.3 when the HDD is not operating.

c) To prevent condensation, avoid sudden changes in temperature.

5.2 Setting

5.2.1 Port Address

Every device that uses the SAS interface has a unique SAS address, and commands use an SAS address to identify each device for I/O operations. Every HDD is assigned a unique SAS address before shipment from the factory, so setting of an address is not required before the HDDs are used.

5.3 Mounting HDDs

5.3.1 Mounting Procedures

Since mounting the HDD depends on the system cabinet structure, determine the work procedures considering the requirements specific to each system. The general mounting method and items to be checked are shown below.

See Section 4.1 for the details of requirements for installing the HDDs.

1) Fix the HDD in the system cabinet with four mounting screws as follows:

   - The HDD has 8 mounting holes (both sides: 2 × 2, bottom: 4). Fix the HDD by using four mounting holes of both sides of the HDD or the bottom.
   - Use mounting screws of which lengths inside the HDD mounting frame are 2.5 mm ±0.5 mm when the screws are tightened (see Figure 4.3).
   - When mounting the HDD, be careful not to damage the PCBA.

2) Confirm the HDA is not touching the frame on the system side excluding the screw installing part after tightening the screws. At least 2.5mm of clearance is required between the HDA and the frame (see Figure 4.3).

3) When using an electric screwdriver, use the screwdriver that does not apply a force on the HDD that would exceed the HDD specifications.

5.4 Checking Operation after Installation and Preparing the HDDs for Use

5.4.1 Checking Initial Operation

The procedure for verifying operation after power-on is explained below.

(1) Initial diagnosis at power-on:

a) When the HDDs are turned on, the HDDs perform the initial self-diagnosis (controller hardware diagnosis). If external LED is connected, it blinks.

b) When the SAS protocol controller diagnosis is completed normally, the HDDs start the LINK RESET sequence defined by the SAS protocol to establish synchronization with the connected SAS devices (e.g., the host system).

c) When the initial diagnosis is completed normally, the HDDs can respond to commands from the host.

(2) Verifying interface connection:

When verification of initial operation after power-on is completed normally, the host system checks whether the HDD connection to the interface is normal. The procedure for this check depends on the host system configuration. The following is a general check procedure:

a) Confirm that the transfer rate and HDD SAS addresses can be recognized during the LINK RESET sequence.

b) Issue the INQUIRY, WRITE BUFFER, and READ BUFFER commands to verify that data is received and transmitted normally in the interface.

(3) Verifying HDD operation:

When the LINK RESET sequence has completed, the host system can issue a spindle motor start instruction and check whether the HDD is ready to operate.

a) The host system instructs the spindle motor to start by sending the NOTIFY (ENABLE SPINUP) primitive to the HDD.

b) The HDDs do not start the motor until the NOTIFY (ENABLE SPINUP) primitive is issued.

c) The HDD enters the ready state within about 60 seconds after the NOTIFY (ENABLE SPINUP) primitive is issued.

d) If the external LED is connected, it blinks (flashes on and off every 0.5 seconds) while the motor is running.

e) After the HDDs enter the ready state, the host system can use the TEST UNIT READY command to confirm that the HDDs are in the ready state. If the external LED is connected, the LED is on or off (depending on the READY LED MEANING setting of Mode Page 19).

(4) Responses to operation errors:

a) Confirm again that connectors are securely attached to cables.

b) Check whether the supply voltage is supplied normally. (Measure the voltage at the power connectors of the HDDs.)

c) Issue the REQUEST SENSE command to collect sense data. When sense data has been collected successfully, perform an analysis to check for recoverable errors, and retry operations for recovery from any such errors.

(5) Checking at abnormal end

When sense data can be obtained, analyze the sense data and retry recovery for a recoverable error. Refer to Chapter 6 "Sense Data and Error Recovery Method" of the SAS INTERFACE SPECIFICATION for further details.

5.4.2 Formatting

Since the HDD is formatted with a specific (default) data format for each model (part number) when shipped from the factory, the disk need not be formatted (initialized) when it is installed in the system.

However, when the system needs data attributes different from the default format, all sides of the disk must be formatted (initialized) according to the procedures below.

The user can change the following data attributes at initialization:

- Logical data block length
- Number of logical data blocks in the user space

This section outlines the formatting at installation. Refer to Subsection 4.1.5 "MODE SELECT (6)", 4.1.6 "MODE SELECT (10)", 4.3.1 "FORMAT UNIT (04)", and Chapter 7 "Disk Media Management" of the SAS INTERFACE SPECIFICATION for further details.

(1) MODE SELECT command

Specify the format attributes on the disk with the MODE SELECT command. The parameters are as follows.

Block descriptor

Specify the size (byte length) of the logical data block in the "data block length" field. To explicitly specify the number of logical data blocks, specify the number in the "number of data blocks" field. Otherwise, specify 0 in "number of data blocks" field. In this case, the currently set value is used.

(2) FORMAT UNIT command

Initialize entire recording surface of the disk with the FORMAT UNIT command. The FORMAT UNIT command initializes entire surface of the disk using the P lists, verifies data blocks after initialization, and allocates an alternate block for a defect block detected with verification. With initialization, the pattern specified with the initialization data pattern field is written into all bytes of all logical data blocks. Only the position information of defect blocks detected with verification is registered in the G list. The specifications are as follows:

a. Specifying CDB

Specify 0 for the "FmtData" bit and the "CmpLst" bit on CDB, 000 for the "Defect List Format" field, and data pattern written into the data block at initialization for the "initializing data pattern" field.

b. Format parameter

When the values in step a. are specified with CDB, the format parameter is not needed.

5.4.3 Setting Parameters

The user can specify the optimal operation mode for the user system environments by setting the following parameters with the MODE SELECT command:

- Error recovery parameter
- Caching parameter
- Control mode parameter

With the MODE SELECT command, specify 1 for the "SP" bit on CDB to save the specified parameter value on the disk. This enables the HDDs to operate by using the parameter value set by the user when power is turned on again.

When the parameters are not set or saved with the MODE SELECT command, the HDDs set the default values for parameters and operates when power is turned on or after reset. Although the HDD operations are assured with the default values, the operations are not always optimal for the system. To obtain the best performance, set the parameters in consideration of the system requirements specific to the user.

This section outlines the parameter setting procedures. Refer to Subsection 4.1.5 "MODE SELECT (6)", 4.1.6 "MODE SELECT (10)" of the SAS INTERFACE SPECIFICATION for further details of the MODE SELECT commands and specifying the parameters.

IMPORTANT

1. At factory shipment of the HDDs, the saving operation for the MODE SELECT parameter is not executed. So, if the user does not set parameters, the HDDs operate according to the default value of each parameter.
2. The MODE SELECT parameter is not saved for each initiator but as the common parameter for all initiator. In the multi-initiator system, parameter setting cannot be changed for each initiator.
3. Once parameters are saved, the saved value is effective as long as next saving operation is executed from the initiator. For example, even if the initialization of the disk is performed by the FORMAT UNIT command, the saved value of parameters described in this section is not affected.
4. When the HDDs, to which the saving operation has been executed on a system, are connected to another system, the user must pay attention to that the HDDs operate according to the saved parameter value if the saving operation is not executed at installation.
5. The saved value of the MODE SELECT parameter is assumed as the initial value of each parameter after the power-on, the HARD RESET sequence, or the LOGICAL UNIT RESET frame.
   The initiator can change the parameter value temporary (actively) at any timing by issuing the MODE SELECT command with specifying "0" to the SP bit in the CDB.

(1) Error recovery parameters

The following parameters are used to control operations such as HDD internal error recovery:

a. Read/write error recovery parameters (page code = 1)

Parameter		Default value
• AWRE:	Automatic alternate block allocation at Write operation	1 (enabled)
• ARRE:	Automatic alternate block allocation at read operation	1 (enabled)
• TB:	Uncorrectable data transfer to the initiator	0 (disabled)
• EER:	Immediate correction of correctable error	1 (enabled)
• PER:	Report of recovered error	0 (disabled)
• DCR:	Suppression of ECC error correction	0 (Correction is enabled.)
• RETRY COUNT AT READ OPERATION		63
• RETRY COUNT AT WRITE OPERATION		63
• RECOVERY TIME LIMIT		30 sec

b. Verify error recovery parameters (page code = 7)

Parameter		Default value
• ERR:	Immediate correction of recoverable error	1 (enabled)
• PER:	Report of recovered error	0 (disabled)
• DTE:	Stop of command processing at successful error recovery	0 (Processing is continued.)
• DCR:	Suppression of ECC error correction	0 (Correction is enabled.)
• RETRY COUNT AT VERIFICATION		63

c. Additional error recovery parameters (page code = 21)

Parameter	Default value
• Retry count at seek error	15

Notes:

1. The user can arbitrarily specify the following parameters according to the system requirements:
   - ARRE
   - AWRE
   - TB
   - PER

2. The user also can arbitrarily specify parameters other than the above. However, it is recommended to use the default setting in normal operations.

(2) Caching parameters (page code = 8)

The following parameters are used to optimize HDD Read-Ahead caching operations under the system environments. Refer to Chapter 3 "Data Buffer Management" of the SAS INTERFACE SPECIFICATION for further details.

Parameter		Default value
• IC:	Initiator control	0 (HDD-specific control (page cache))
• RCD:	Disabling Read-Ahead caching operations	0 (enabled)
• WCE:	Write Cache Enable	1 (enabled)
• MF:	Specifying the multipliers of "MINIMUM PRE-FETCH" and "MAXIMUM PRE-FETCH" parameters	0 (Specifying absolute value)
• DISC:	Prefetch operation after track switching during prefetching	1 (enabled)
• FSW:	Write methods of multiple blocks	1 (write as transfer orders)
• DISABLE PRE-FETCH TRANSFER LENGTH		X'FFFF'
• MINIMUM PRE-FETCH		X'0000'
• MAXIMUM PRE-FETCH		X'0000'
• MAXIMUM PRE-FETCH CEILING		X'FFFF'
• NUMBER OF CACHE SEGMENTS		X'08'

Notes:

1. When Read-Ahead caching operations are disabled by the caching parameter, these parameter settings have no meaning except write cache feature.

2. Determine the parameters in consideration of how the system accesses the disk. When the access form is not determined uniquely because of the processing method, the parameters can be re-set actively.

3. For sequential access, the effective access rate can be increased by enabling Read-Ahead caching operations and Write Cache feature.

(3) Control mode parameters (page code = A)

The following parameters are used to control the tagged queuing and error logging.

a. Control mode parameters

Parameter	Default value
• QUEUE ALGORITHM MODIFIER	0 (Execution sequence of read/write commands is optimized.)

(4) Port control parameters (page code=19)

The following parameters are used to control the ready LED signal behavior.(when the external LED is connected).

Parameter	Default value
• READY LED MEANING	0 (External LED is on when HDD is ready)

5.5 Dismounting HDDs

Since the method and procedure for dismounting the HDD for replacement of the HDD, etc. depends on the locker structure of the system, etc., the work procedure must be determined in consideration of the requirements specific to the system. This section describes the general procedure and notes on dismounting the HDD.

⚠CAUTION	
 **Instructions**	High temperature To prevent injury such as burn, do not touch the HDD while it is hot. The HDA and LSI become hot during operation and remain hot immediately after turning off the power.
 **Instructions**	Damage When dismounting the HDD which is mounted on the system while power is supplied; 1) Stop the spindle motor by a START STOP UNIT command. It takes about 15 seconds for the spindle motor to stop completely. 2) Then, dismount the HDD using such as the HDD mounting/dismounting mechanism of the system. When removing the HDD, avoid exposing it to shock or vibration. Just in case, stop dismounting once and wait until the spindle motor stops (about 15 seconds) when SAS connector breaks off contact.
 **Instructions**	Damage When dismounting the HDD which is mounted on the system while power is not supplied; Dismount the HDD using such as the HDD mounting/dismounting mechanism of the system. When removing the HDD, avoid exposing it to shock or vibration..
 **Instructions**	Damage When storing or transporting the HDD, put it in the antistatic bag (refer to Section 5.1 and 6.5).

CHAPTER 6 Diagnostics and Maintenance

This chapter describes diagnostics and maintenance.

6.1 Diagnostics

6.1.1 Self-diagnostics

The HDDs have the following self-diagnostic function. This function checks the basic operations of the HDDs.

- Initial self-diagnostics
- Online self-diagnostics (SEND DIAGNOSTIC command)

Table 6.1 lists the contents of the tests performed with the self-diagnostics. For a general check of the HDDs including the operations of the host system and interface, use a test program that runs on the host system (see Subsection 6.1.2).

Table 6.1 Self-diagnostic functions

Test contents	Initial self-diagnostics	SEND DIAGNOSTIC command	
		Self Test=1 Unit Offline=0	Self Test=1 Unit Offline=1
Hardware function test	○	○	○
Seek test			○
Write/read test (Cylinder for internal test)			○

Note:

○ indicates the tests to be executed and arrows show the sequence of execution.

Brief test contents of self-diagnostics are as follows.

a. Hardware function test

This test checks the basic operation of the controller section, and contains following test.

- RAM (microcode is stored)
- Peripheral circuits of microprocessor (MPU)
- Data buffer

b. Seek test

This test checks the positioning operation of the HDD using several seek modes (2 points seek, 1 position sequential seek, etc.). The positioning operation is regarded as success when the seek operation to the target cylinder is completed.

c. Write/read test

This test checks the write/read function by using the Internal test space of the HDD.

(1) Initial self-diagnostics

When the HDDs are turned on, they run the initial self-diagnostics. The initial self-diagnostics test the basic operations of hardware functions.

If the initial self-diagnostics detects an error, the HDDs in this state post the CHECK CONDITION status to all I/O operation requests except the REQUEST SENSE command. The initiator can collect sense data when the CHECK CONDITION status is posted. If the external LED is connected, it blinks (at 0.4-second intervals).

Sense data contains detailed information on the error detected by the initial self-diagnostics.

When sense data has been collected after the CHECK CONDITION status has been posted, the CHECK CONDITION status continues. This status can be cleared only when the HDDs are turned off and turned on again. When the status is cleared, the HDDs run the initial self-diagnostics again.

The HDDs do not reply to requests from the host system for a maximum of 2 seconds after the start of the initial self-diagnostics. Thereafter, the HDDs can accept I/O operation requests normally, but any received command, except commands that are executable even in the not ready state, is terminated with the CHECK CONDITION status until the spindle motor reaches the normal rotational speed and the HDDs become ready. The commands that are executable even in the not ready state are executed in parallel with the initial self-diagnostics, or they are queued by the command queuing feature and executed when the initial self-diagnostics is completed.

If the initial self-diagnostics detect an error, the CHECK CONDITION status is posted for all of the commands received and queued during the initial self-diagnostics.

(2) Online self-diagnostics (SEND DIAGNOSTIC command)

The initiator can make the HDDs execute self-diagnostics by issuing the SEND DIAGNOSTIC command.

The initiator specifies the execution of self-diagnostics by setting 1 for the SelfTest bit on the CDB in the SEND DIAGNOSTIC command and specifies the test contents with the UnitOfl bit.

When the UnitOfl bit on the CDB is set to 0, the HDDs execute the hardware function test only once. When UnitOfl bit is set to 1, the HDDs execute the hardware function test, seek (positioning) test, and data write/read test for the Internal test space only once.

a. Error recovery during self-diagnostics

During the self-diagnostics specified by the SEND DIAGNOSTIC command, when the recoverable error is detected during the seek or the write/read test, the HDDs perform the error recovery according to the MODE SELECT parameter value (read/write error recovery parameter, additional error recovery parameter) which the initiator specifies at the time of issuing the SEND DIAGNOSTIC command.

PER	Operation of self-diagnostics
0	The self-diagnostics continues when the error is recovered. The self-diagnostics terminates normally so far as the unrecoverable error is not detected.
1	The self-diagnostics continues when the error is recovered. If the unrecoverable error is not detected, the consecutive tests are executed till last test but the self-diagnostics terminates with error. The error information indicates that of the last recovered error.

b. Reporting result of self-diagnostics and error indication

When all specified self-diagnostics terminate normally, the HDDs post the GOOD status for the SEND DIAGNOSTIC command.

When an error is detected in the self-diagnostics, the HDDs terminate the SEND DIAGNOSTIC command with the CHECK CONDITION status.

When the CHECK CONDITION status is posted, sense data contains detailed information on the error detected by the initial self-diagnostics.

The HDD status after the CHECK CONDITION status is posted differs according to the type of the detected error.

a) When an error is detected in the seek or write/read test, the subsequent command can be accepted correctly. When the command other than the REQUEST SENSE is issued from the same initiator, the error information (sense data) is cleared.
b) When an error is detected in the hardware function test, the HDDs post the CHECK CONDITION status for all I/O operation request except the REQUEST SENSE command. The error status is not cleared even if the error information (sense data) is read. Only when the power is turned off or re-turned on, the status can be cleared. When this status is cleared, the HDDs execute the initial self-diagnostics again (see item (1)).

Refer to Subsection 4.4.1 "SEND DIAGNOSTIC (1D)" of the SAS INTERFACE SPECIFICATION for further details of the command specifications.

6.1.2 Test Programs

The basic operations of the HDD itself can be checked with the self-diagnostic function. However, to check general operations such as the host system and interface operations in a status similar to the normal operation status, a test program that runs on the host system must be used.

The structure and functions of the test program depend on the user system requirements. Generally, it is recommended to provide a general input/output test program that includes devices connected to the input/output devices on other I/O ports.

Including the following test items in the test program is recommended to test the HDD functions generally.

(1) Interface test

The operations of the data buffer on the HDDs are checked with the WRITE BUFFER and READ BUFFER commands.

(2) Basic operation test

The basic operations of the HDDs are checked by executing self-diagnosis with the SEND DIAGNOSTIC command (see Subsection 6.1.1).

(3) Random/sequential read test

The positioning (seek) operation and read operation are tested in random access and sequential access modes with the READ, or VERIFY command.

6.2 Maintenance

See Section 5.1 and 6.5 for notes on packaging and handling when returning the HDD.

⚠CAUTION	
 **Instructions**	Data loss Save data stored on the HDD to other media before requesting repair. Toshiba assumes no liability if data is corrupted during servicing or repair.

6.2.1 Precautions

Take the following precautions to prevent injury during maintenance and troubleshooting:

⚠CAUTION	
 **Prohibited**	Electrical shock Do not touch the HDDs while power-feeding.
 **Instructions**	High temperature To prevent injury such as burn, do not touch the HDD while it is hot. The HDA and LSI become hot during operation and remain hot immediately after turning off the power.

Take the following precautions to prevent HDD damage during maintenance and troubleshooting:

⚠CAUTION	
 **Prohibited**	Damage 1）Do not use a conductive cleaner to clean the HDDs. 2）Do not remove any labels from the HDD or deface the HDDs in any way. 3）Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy HDDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.
 **Instructions**	Damage Always ground yourself with such as a wrist strap connected to ground before handling. ESD (Electrostatics Discharge) may cause the damage to the device.

6.2.2 Maintenance Requirements

(1) Preventive maintenance

Preventive maintenance is not required.

(2) Service life

See "(3) Service life," in Subsection 2.1.5.

(3) Parts that can be replaced in the field

The PCBA cannot be replaced in the field. The HDA cannot be replaced in the field.

(4) Service system and repairs

Toshiba has the service system and repair facility for the HDD. Contact Toshiba representative to submit information for replacing or repairing the HDD. Generally, the following information must be included:

a) Model part number (P/N), revision number, serial number (S/N), and date of manufacturing

b) Error status
- Date when the error occurred
- System configuration
- Environmental conditions (temperature, humidity, and voltage)

c) Error history

d) Error contents
- Outline of inconvenience
- Issued commands and specified parameters
- Sense data
- Other error analysis information

6.2.3 Maintenance Levels

If an HDD is faulty, replace the whole HDD since repair requires special tools and environment. This section explains the two maintenance levels.

(1) Field maintenance (HDD replacement)

- This replacement is done at the user's site.
- Replacement uses standard tools.
- Replacement is usually done by the user, retail dealer, distributor, or OEM engineer.

(2) Factory maintenance (parts replacement)

- This replacement can only be done by Toshiba.
- Replacement includes maintenance training and OEM engineer support. OEM engineers usually support retail dealers and distributors.
- Replacement uses factory tools and test equipment.

6.2.4 Tools and Test Equipment

HDD troubleshooting and repair in the field require only standard hand tools. No special tools or test equipment are required.

This document does not describe the factory-level tools and test equipment.

6.2.5 Tests

This HDD can be tested in the following ways:

- Initial seek operation check (See Subsection 6.3.1)
- Operation test (See Subsection 6.3.2)
- Diagnostic test (See Subsection 6.3.3)

Figure 6.1 shows the flow of these tests.

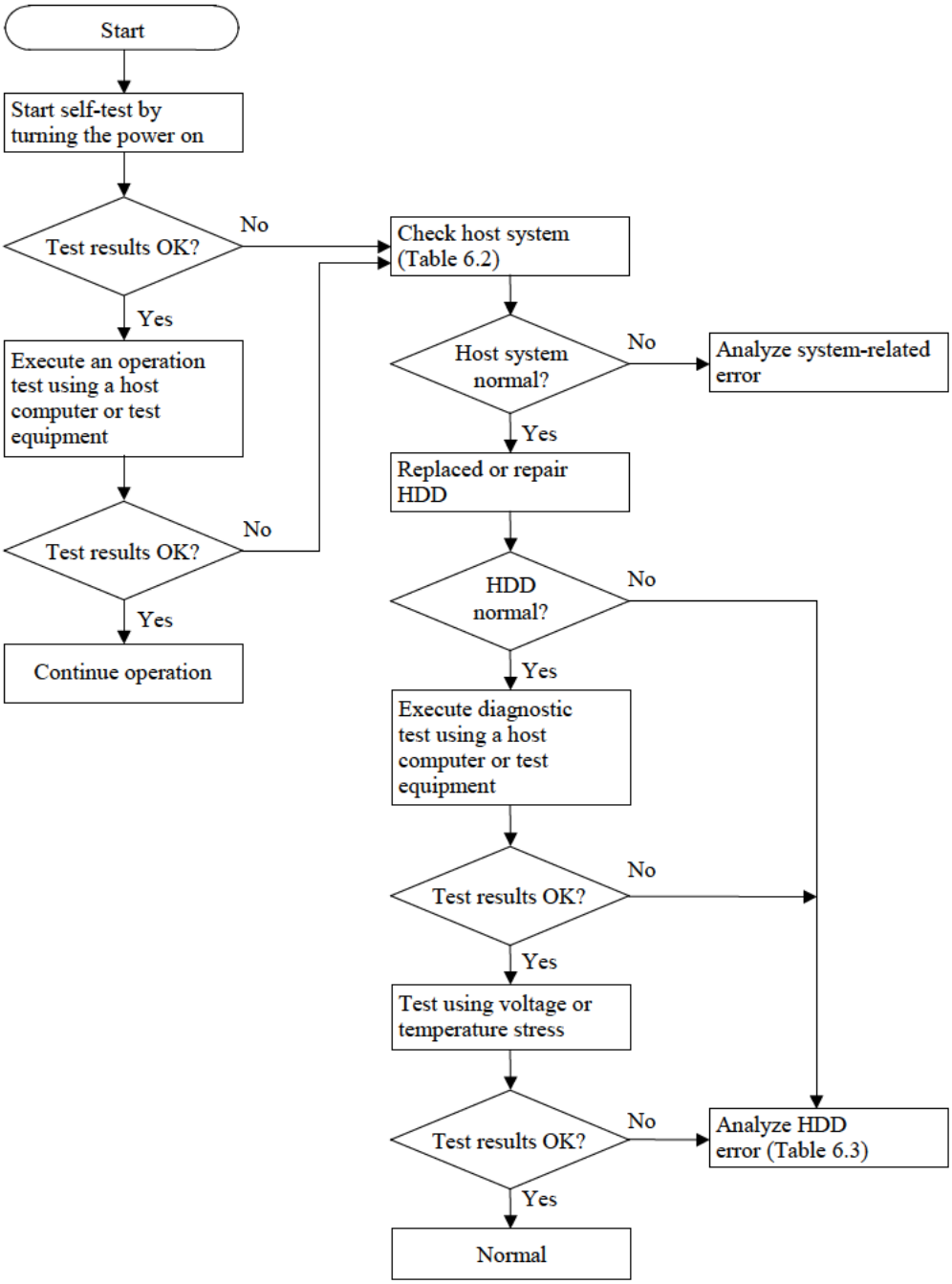


Figure 6.1 Test flowchart

6.3 Operation Check

6.3.1 Initial Seek Operation Check

If an error is detected during initialization by the initial seek operation check routine at power-on, the spindle motor of the HDD stops, and then the HDD becomes unusable.

For an explanation of the operation check before the initial seek, refer to the Section 5.4.

6.3.2 Operation Test

While the host computer is processing data, the HDDs monitor HDD operation including data processing, command processing, and seek operations. If the HDDs detect an error, the HDDs post the error to the initiator. The initiator then posts the error to the user.

The user may detect an intermittent or nonfatal error such as abnormal noise, abnormal odor, or very slow operation.

An error posted in an operation test must be investigated. The user can replace the HDD to see whether the error was caused by the HDD.

Often, errors posted in an operation test may be caused by the host system. Possible causes include insufficient power capacity, loose cable connection, insufficient timing or insufficient mechanical play, and other problems related to the systems.

If an operation error is detected by the error detection circuit of the HDD, an interrupt occurs. The interrupt is posted to the MPU on the PCBA. The MPU stops the currently processed command, and causes the CHECK CONDITION status to post the error to the initiator.

When receiving the CHECK CONDITION status, the initiator collects detailed information via SENSE data.

To analyze the error posted in the operation test, reconstruct the conditions in which the error occurred. Then, start troubleshooting the whole host system by replacing the HDD.

6.3.3 Diagnostic Test

The diagnostic test is executed to find a faulty subassembly in a faulty HDD, or to check HDD performance. This test is usually a combination of specific HDD functions or group of functions. This test may be executed using a different host computers or test equipment and away from the environment where the error first occurred.

To analyze the error posted in the diagnostic test, reconstruct the conditions in which the error occurred. Then, look for a possibly faulty subassembly or part of the HDD.

The procedures to be used in this test depend largely on the type of test equipment used, and are not covered by this document.

6.4 Troubleshooting

6.4.1 Outline of Troubleshooting Procedures

This section explains the troubleshooting procedures for HDD errors.

Depending on the maintenance level, analyze the error to detect a possibly faulty part (HDD, or HDD part).

Full-scale troubleshooting is usually required if the error cause is not known. If the error cause is clear (e.g., abnormal noise in HDA or burning of the PCBA), troubleshooting is straightforward.

6.4.2 Troubleshooting with HDD Replacement in the Field

At this level of maintenance, we recommend replacing the HDD as a unit. If replacing the HDD rectifies the fault, return the removed HDD to Toshiba, for test and repair. If the newly installed HDD does not rectify the fault another part of the system is faulty.

Table 6.2 summarizes system-level field troubleshooting. Troubleshooting must be done in the field, to find faulty part (HDD or system).

Table 6.2 System-level field troubleshooting

Item	Recommended work
DC power level	Check that the DC voltage is within the specified range (±5%). For +5V DC, measure the voltage between pin 20 (+5V) of the interface connector and the nearest PCBA mounting screw (GND) from the interface connector, and confirm the value is from 4.75 to 5.25 VDC. For +12V DC, measure the voltage between pin 2 (+12V) of the interface connector and the nearest PCBA mounting screw (GND) from the interface connector, and confirm the value is from 11.4 to 12.6 VDC.
Electrical noise	Make sure the maximum ripple peak-to-peak value of +5V DC is within 250 mV and +12V DC is within 250 mV. Make sure the high frequency noise (over 20 MHz) is less than 100 mVp-p.
System cables	Check that all system cables are connected correctly.
System diagnostic test	When possible, execute the system level diagnostic routine as explained in the host computer manual. This gives a detailed report of a possible fault.
Intermittent or nonfatal errors	Check the AC voltage from the power supply. Check the DC voltage level at the power connector for the HDD. If the AC voltage level is abnormal or there is a lot of electrical noise, notify the user of the error. If the DC voltage level is unstable, replace the power supply unit. If possible, replace the HDD. If replacing the HDD does not eliminate the error, the removed HDD is probably not faulty. To continue error analysis, refer to the hardware and software manuals supplied with the system.

6.4.3 Troubleshooting at the Repair Site

For maintenance at this level, we recommend additional testing of the HDD and signal checking.

The sense data posted from the HDDs help with troubleshooting. This sense data makes the error type clear (functional, mechanical, or electrical error). CHAPTER 7 error analysis by sense data, and gives supplementary information on finding the error cause (faulty part).

Table 6.3 lists how to detect a faulty HDD subassembly. This fault finding requires a working host computer or HDD test equipment to recreate the error conditions.

If the detected error cannot be recreated in an ordinary test, HDD conditions can be changed to force the error to recur. This is done by changing the DC voltage or the ambient temperature of the HDD.

If the error does not recur with changed conditions, the HDD is not faulty. If no error occurs in the HDD test, notify the user of the test results, and find out from the user the environment conditions where the HDD is used.

Table 6.3 HDD troubleshooting

Item	Recommended action
Frequent or repeated seek errors	Collect sense data, and see CHAPTER 7. Replace the HDD, and check that the test method is correct. If the error recurs, it is likely that the HDD is normal but the test method is incorrect.
Intermittent or nonfatal errors	Replace the HDD, and check that the test method is correct. If the error recurs, it is likely that the HDD is normal but the test method is incorrect. To check performance, change the HDD conditions by changing the voltage or temperature.

If the HDD error recurs or a possibly faulty part is found by troubleshooting, return the complete HDD to Toshiba for repair. A media defect list must be included with the HDD returned to Toshiba.

If the possibly faulty part is the HDA, return the whole HDD to Toshiba for repair. Also if a clear error (erroneous servo track information or noisy HDD) is detected in the HDA, return the whole HDD to Toshiba. A media defect list must be included with the HDD returned to Toshiba.

⚠CAUTION	
Prohibited	Damage 1) Do not use a conductive cleaner to clean the HDDs. 2) Do not remove any labels from the HDD or deface the HDDs in any way. 3) Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy HDDs, whether in whole or in part. Failure to do so voids any warranty, expressed or implied.

6.4.4 Troubleshooting with Parts Replacement in the Factory

This document does not cover troubleshooting at the factory level.

6.4.5 Finding Possibly Faulty Parts

Finding possibly faulty parts in the field was explained in Subsection 6.4.2. This document does not cover finding possibly faulty parts at the factory level.

6.5 Packaging

When the HDD is returned, the following methods are recommended.

6.5.1 Bag Packaging

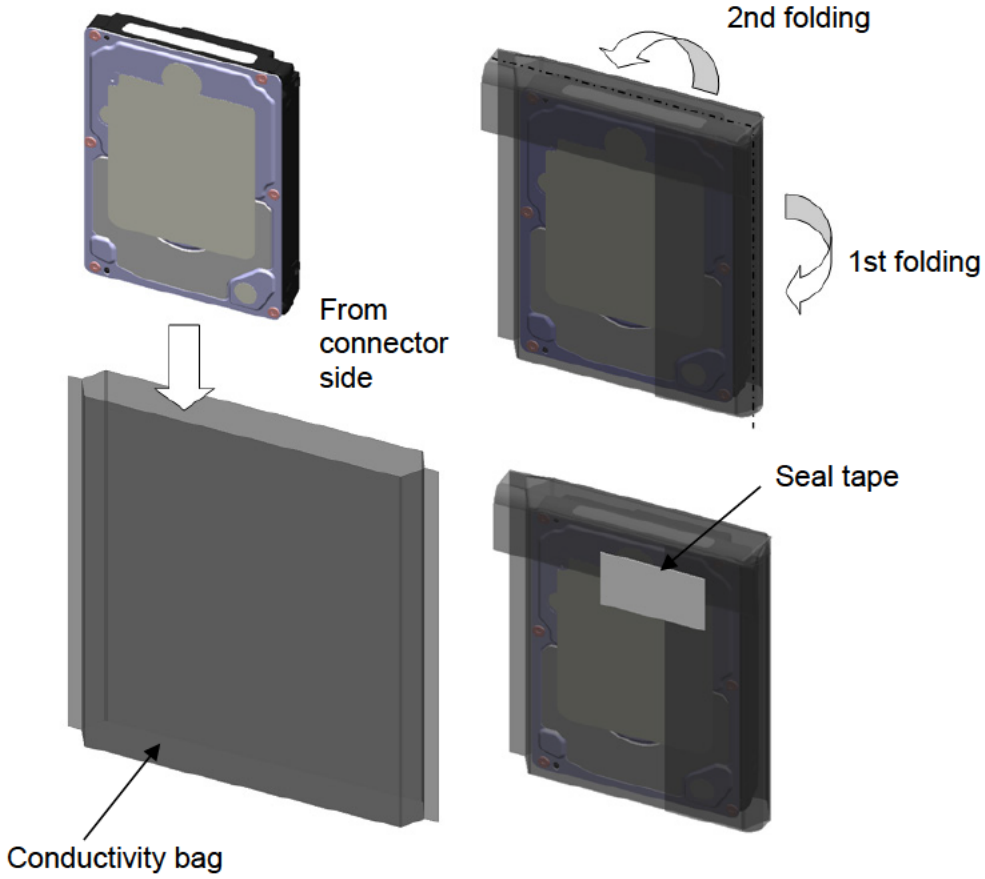


Figure 6.2 Bag packaging

(1) Put the HDD in the conductivity bag.

The HDD shall be put in the bag from the connector side.

(2) Fold the bag, and then seal the bag with the seal.

6.5.2 Box Packaging

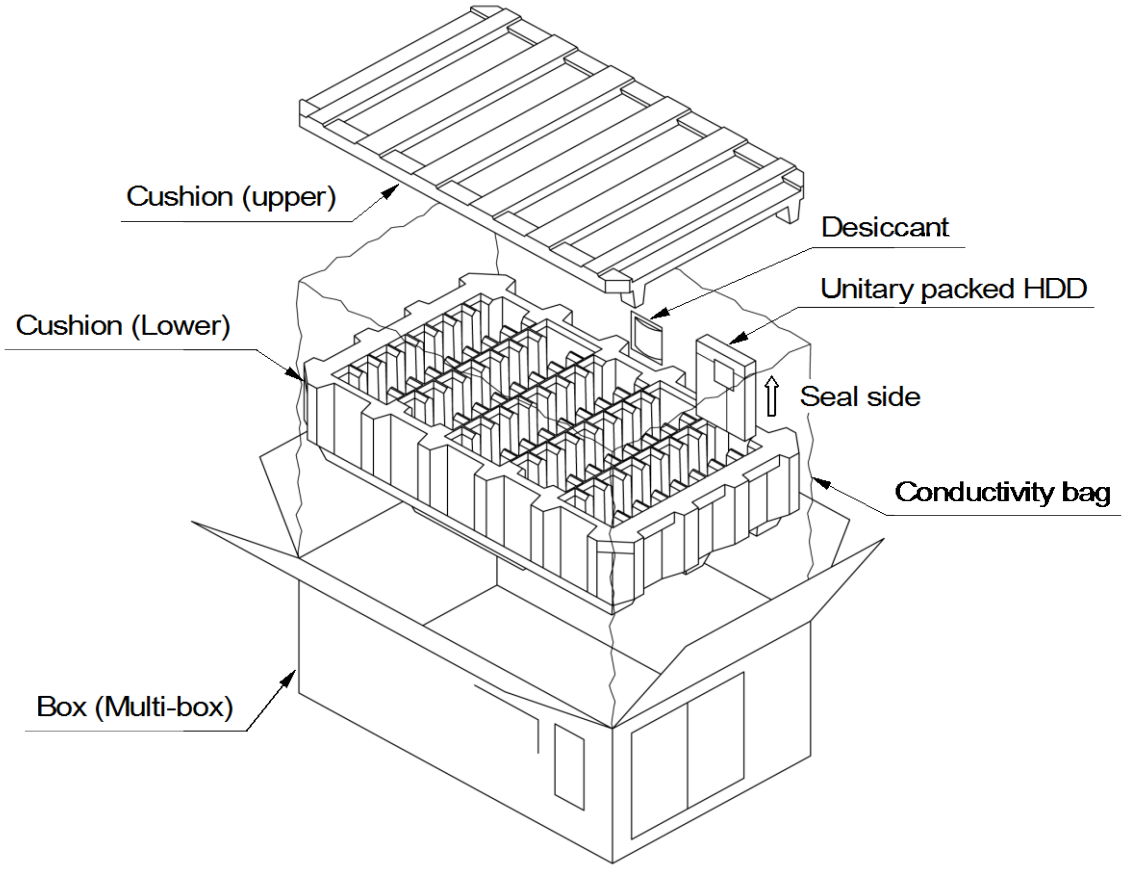


Figure 6.3 Box packaging

(1) Put the conductivity bag (large) into the multi-box, in addition, put the cushion (lower) into the bag.

(2) Put the bag packed HDDs into the cushion (lower).

- Insert the seal side upward.
- In the fraction shipment, empty the slots in the Figure 6.4 where figure is larger than the number of shipment, and fill other slots with the HDDs.

(3) Put the desiccants between the conductivity bag (large) and the cushion (lower) in the box.

(4) Put the cushion (upper) into the box.

(5) Seal the conductivity bag (large) with the packaging tape.

(6) Close the box with the packaging tape. (Attach the tape in 'H' figure at the top.)

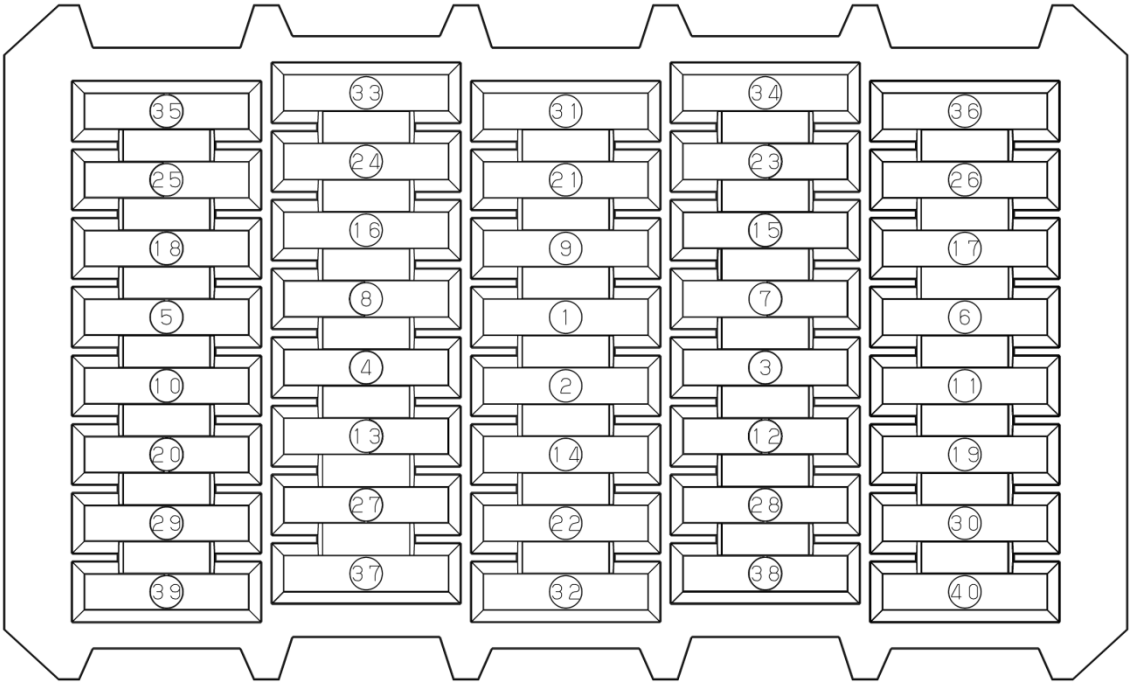


Figure 6.4 Fraction packaging

CHAPTER 7 Error Analysis

This chapter explains in detail how sense data collected from an HDD is used for troubleshooting. Sense data reflects an error in the HDD, and helps with troubleshooting.

7.1 Sense Data Collection

7.1.1 Sense data

When HDDs post a CHECK CONDITION status, the current command or queued command is cleared. In such a case, the HDDs generate sense data about the command-issuing initiator. The initiator can read the sense data by reading the sense data added to the response frame of the command where an error occurred (Auto Sense function).

A set of sense key, additional sense code and additional sense code qualifier is often used for failure investigation. In this section, it is described troubleshooting based on the set of sense key, additional sense code and additional sense code qualifier. Unless otherwise specified, "sense data" means the above three codes. When sense data is represented as (x-xx-xx), the leftmost x is a sense key, the middle xx is an additional sense code, and the rightmost x is an additional sense code qualifier.

7.1.2 Sense data format

Sense data is reported by REQUEST SENSE command or Auto Sense function.

In response to REQUEST SENSE command, HDD reports Sense data in the fixed form or the descriptor form according to the configuration of DESC bit of CDB. As for Auto Sense function, HDD reports it in the fixed form or the descriptor form according to the setting of D_SENSE bit on mode parameter page A (control mode page).

One head byte in Sense data is a response code, and it describes the error type and Sense data format as shown in Table 7.1.

Table 7.1 Response code

Response code	Explanation
0x00～0x6F	(Reserved)
0x70	Current error of fixed form (*1), (*2)
0x71	Deferred error of fixed form(*1)
0x72	Current error of descriptor form
0x73	Deferred error of descriptor form
0x74～0x7E	(Reserved)
0x7F	Vender specific(Reserved)

(*1) In case of the fixed form, Valid bit is allocated in the most upper bit in the first byte of Sense data, and the first byte of Sense data might become 0xF0 or 0xF1.
(*2) In the following cases, the response code is defined as 0x70 regardless of DESC bit or D_SENSE bit.
・When Additional Sense Code (ASC) is 0x29
・When ASC and Additional Sense Code Qualifier (ASCQ) are Mode Parameter Changed (0x2A01)

7.1.3 Fixed form sense data

HDD provides 48 bytes Sense data in the fixed form. The fixed form sense data format is shown in Table 7.2.

IMPORTANT

(1) In the specifications, each device is permitted to define whatever it chooses after byte 18 of the expanded sense data, and the length and format differ for each device. The length of expanded sense data is displayed in the sense data, so by analyzing the sense data which it receives, the INIT can know its effective length.

(2) In the REQUEST SENSE command, even if a Transfer byte length that is shorter than the length of the sense data supported by the device which is the object of the command, the command will terminate normally, but in that case, some of the sense data only will be received and the remaining information will be lost. Sufficient caution should be exercised with regard to the devices connected to the INIT and all the sense data of those devices should be read.

Table 7.2 Fixed form sense data format

	Byte \ Bit	7	6	5	4	3	2	1	0
Basic information	0	Valid	X '70' or X '71' (error code)						
	1	X '00'							
	2	0	0	ILI	0	Sense key			
	3	[MSB]	Information						
	4								
	5								
	6								[LSB]
	7	X '28' (additional sense data length)							
	8	[MSB]	Command-specific information						
	9								
	10								
	11								[LSB]
	12	Additional sense code							
	13	Additional sense code qualifier							
	14	X '00'							
	15	SKSV	Sense key-specific information						
	16								
	17								
Additional information	18	0	0	0	Port	0	0	0	0
	19	CDB operation code							
	20	Detail information							
	47								

ILI: Incorrect Length Indicator
MSB: Most Significant Byte
LSB: Least Significant Byte
SKSV: Sense Key Specific Valid

7.1.4 Descriptor form sense data

7.1.4.1 Descriptor form sense data format

Table 7.3 shows the descriptor form sense data format.
One head byte of the sense data becomes 0x72 (current error) or 0x73 (Deferred error).

Table 7.3 Descriptor form sense data format

Byte \ Bit	7	6	5	4	3	2	1	0
0	0	Response code (0x72/0x73)						
1	Reserved				Sense key			
2	Additional sense code (ASC)							
3	Additional sense code qualifier (ASCQ)							
4	Reserved							
5	Reserved							
6	Reserved							
7	Sense code length (n-7)							
8	Sense data descriptor 0							
	Sense data descriptor x							
n								

The sense code length shows the total number of bytes including sense key, Additional sense code (ASC), and Additional sense code qualifier (ASCQ) are similar to the one of a fixed form.

Table 7.4 shows the sense data descriptor type.

Table 7.4 Sense data descriptor type Table

type	Explanation	Reference	Data length
0x00	Information sense data	Error LBA, Byte number difference	12
0x01	Command specific information sense data	Reassign failure LBA	12
0x02	Sense key specific sense data	Retry count, Progress rate and others	8
0x03	FRU sense data	SMART information	4
0x04	Stream command sense data	(unused)	4
0x05	Block command sense data	ILI bit for READ/WRITE LONG command	4
0x06-0x09	(unsupport)	-	-
0x0A	Progress indication sense data	Stage of completion	8
0x0B-0x7F	Reserved	-	-
0x80	Vendor specific sense data	Byte 18～47 of fixed form sense data	32
0x81-0xFF	Reserved	-	-

The sense data descriptor length shows the total bytes long of the sense data descriptor.

7.1.4.2 Information sense data descriptor

Information sense data is a similar with the sense data of a fixed form (Byte 3-6), and it reports on error LBA and byte number difference.
"Valid" One is always reported to bit. When data is four bytes longs, the first four bytes report on oar 0x00.

Table 7.5 Information sense data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Sense data descriptor type (0x00)							
1	Sense data descriptor length (0x0A)							
2	Valid	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Information							
・・								
11								

7.1.4.3 Command specific information sense data descriptor

The command specific information sense data is a similar to the sense data of a fixed form information (byte 0x08-0x11), and first LBA etc. that became the unalternation processing in the defect descriptor are reported.
When data is four bytes longs, the first four bytes report on oar 0x00.

Table 7.6 Command specific information sense data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Sense data descriptor type (0x01)							
1	Sense data descriptor length (0x0A)							
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	Command specific information							
・・								
11								

7.1.4.4 Sense key specific data descriptor

Sense key specific data reports on the field pointer, retry count, and the progress rate, etc. by the value of the sense key as shown in the following. When sense key specific data is transmitted, data similar to Byte15-17 of the sense data of a fixed form is reported.

Table 7.7 Sense key specific data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Sense data descriptor type (0x02)							
1	Sense data descriptor length (0x06)							
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	SKSV	Sense key specific data						
5								
6								
7	0	0	0	0	0	0	0	0

"SKSV"Bit always reports on 1

Table 7.8 Sense key specific information

Sense key	Explanation
Illegal Request	Field pointer
Recovered Error Hardware Error Medium Error	Retrying count
Not Ready No Sense	Progress rate display
Copy Aborted	Segment pointer (unused)
Unit Attention	Overflow of Unit Attention state cue (unused)
Others	Sense key specific information doesn't exist.

7.1.4.5 Field pointer sense key specific data descriptor

Field pointer reports in the Byte of CDB or the parameter how many there is an error. When two or more errors exist, it reports on the position of the error of the head of CDB (Or, parameter). They are treated at all for the parameter across multiple Bytes.

Table 7.9 Field pointer sense key specific data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	SKSV	C/D	0	0	BPV	Bit pointer		
1	Field pointer							
2								

7.1.4.6 Actual retry count sense key specific data descriptor

Retrying count reports on retrying count actually given.

Table 7.10 Actual retry count sense key specific data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	SKSV	0	0	0	0	0	0	0
1	Actual Retry count							
2								

7.1.4.7 Progress indicator sense key specific data descriptor

The progress rate display reports on the progress rate of FORMAT UNIT/Self Test.

Table 7.11 Progress indicator sense key specific data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	SKSV	0	0	0	0	0	0	0
1	Progress indicator							
2								

7.1.4.8 Block command sense data descriptor

When the transfer length abnormal of the READ LONG/WRITE LONG command is executed. It is shown that the value reported by the information sense data is byte number difference when this bit is one.

Table 7.12 Block command sense data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Sense data descriptor type (0x05)							
1	Sense data descriptor length (0x02)							
2	0	0	0	0	0	0	0	0
3	0	0	ILI	0	0	0	0	0

7.1.4.9 Progress indicator sense data descriptor

Progress level display reports on the stage of completion of FORMAT UNIT/Self Test.

Table 7.13 Progress indicator sense data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Sense data descriptor type (0x0A)							
1	Sense data descriptor length (0x06)							
2	Sense key							
3	Additional sense code(ACS)							
4	Additional sense code qualifier (ACSQ)							
5	0	0	0	0	0	0	0	0
6	Progress indicator							
7								

7.1.4.10 Vendor specific sense data descriptor

Table 7.14 Vendor specific sense data descriptor format

Byte \ Bit	7	6	5	4	3	2	1	0
0	Sense data descriptor type (0x80)							
1	Sense data descriptor length (n-1)							
2	Vendor specific information							
n								

7.2 Sense Data Analysis

7.2.1 Error Information Indicated with Sense Data

Table 7.15 lists the definition of sense data. For details of the following sense data, refer to Chapter 6 "Sense Data Error Recovery Methods" of the SAS INTERFACE SPECIFICATION.

Subsection 7.2.2 onwards explain troubleshooting using sense data.

Table 7.15 Definition of sense data

Sense data			Definition
Sense key	Additional sense code	Additional sense code qualifier	
3	0C	03	A write to a disk terminated abnormally.
4	32	00	No usable alternate block area exists. Or alternate block processing cannot be performed due to control table overflow.
	40	xx	An error occurred in power-on self-diagnosis.
	C4	xx	An HDD error occurred.
1	1x	xx	A disk read error occurred, but terminated normally with error recovery functions.
3	1x	xx	A disk read error occurred.
E	1D	00	Data discrepancy found by VERIFY command byte check.
5	2x	xx	An illegal request error, such as an invalid operation code, occurred.
4	44	xx	A hardware error occurred inside HDDs.
B	4B	xx	An interface error was issued.
	4E	00	An overlap command was issued.

7.2.2 Sense Data (3-0C-03), (4-32-00), (4-40-xx), (4-C4-xx), and (4-44-xx)

Sense data (3-0C-03), (4-32-00), (4-40-xx), (4-C4-xx), and (4-44-xx) indicate one of the following:

- A target sector could not be detected using the sector counter.
- A seek process overran the specified time.
- A write to a disk terminated abnormally.
- An error occurred in power-on self-diagnosis.
- An HDD error occurred.

The symptoms above are generally caused by an error in a PCBA or HDA.

7.2.3 Sense Data (1-1x-xx), (3-1x-xx) and (E-1D-00): Disk read error

If sense data (1-1x-xx), (3-1x-xx) or (E-1D-00) occurs frequently in a specific block of a disk, there is disk damage that was not recorded in the media defect list. In this case, assign an alternate block to the error-detected block using a REASSIGN BLOCKS command. For an explanation of the REASSIGN BLOCKS command, refer to Subsection 4.3.2 "REASSIGN BLOCKS (07)" of the SAS INTERFACE SPECIFICATION.

If this error occurs in different blocks, a PCBA or HDA may be faulty.

7.2.4 Sense Data (5-2x-xx), (B-4B-xx) and (B-4E-00): interface error

Sense data (5-2x-xx), (B-4B-xx) and (B-4E-00) indicate one of the following symptoms:

- An invalid or unsupported command was issued, or invalid or unsupported parameters were specified.
- An interface error occurred.
- A hardware error occurred inside HDDs.

If this error occurs, the PCBA or the interface may be faulty.

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